Engineer Instruction Manual
No. 2

Military Photography

Prepared Under the Direction of
The Chief of Engineers, United States Army

1917

WASHINGTON
GOVERNMENT PRINTING OFFICE
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FIG. 1.

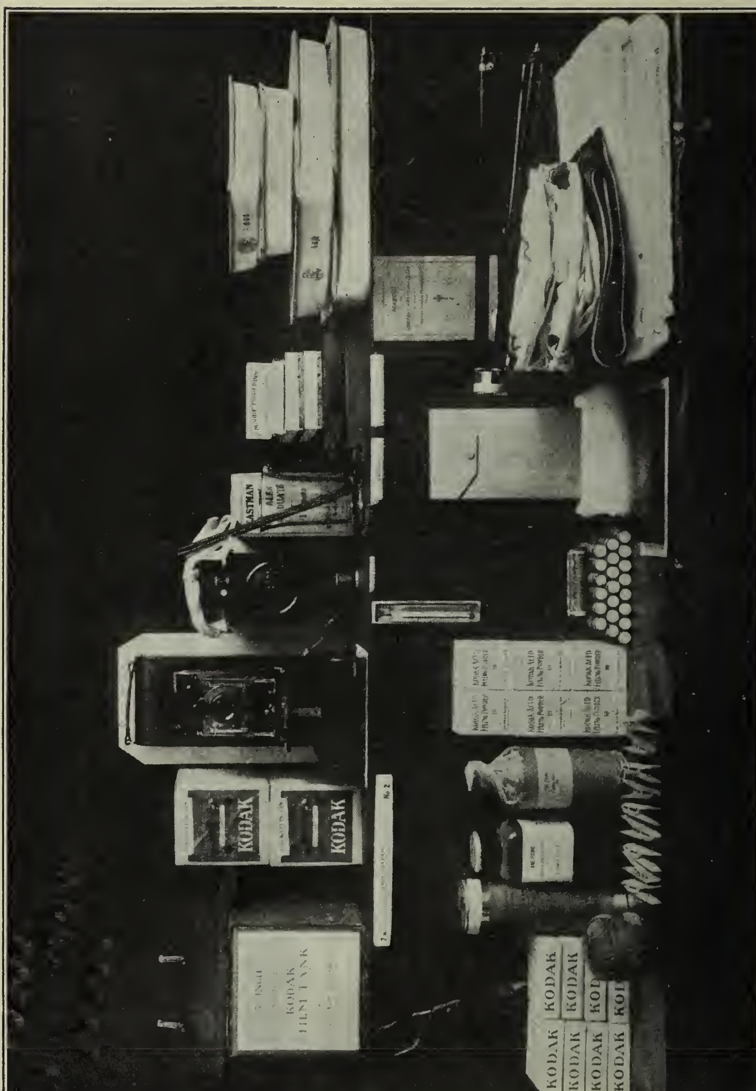
KODAK
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Fig. 2.

PHOTOGRAPHIC EQUIPMENT OF ENGINEER TROOPS.

1. Each Engineer company is provided with a 3A autographic and each regiment and mounted battalion unit with a 3A Graflex camera. The remainder of the equipment is about the same for all units, except that the Graflex camera outfits have about twice the amount of supplies as the other. Both of these standard equipments are shown in the plates.

I. LENSES.[1]

2. The most important part of any camera is its lens. Its function is to bring together the light rays reflected from all points of the objects being photographed and to concentrate them so as to form an image on the photographic film or plate. A lens deflects all rays passing through it in the direction of its thickest portions. A convex lens, therefore, tends to bring parallel rays to a focus or single point.

3. The distance between this point and the center of the lens is its focal length. Lenses are commonly described as being of so many inches focus, which means that parallel or essentially parallel rays are focused in a plane located at that distance from the center of the lens. This plane is called the principal focal plane of the camera. It must not be concluded, however, that the film is always placed in this plane. The nearer the lens is brought to the object to be photographed the further back does the focus recede. It follows, then, that objects in different planes or at different distances from the camera can not be focused simultaneously, unless all are so distant that rays of light reaching the camera from them are essentially parallel.[1]

[1] The information contained in Chapters I to XI is based largely on the publications of the Eastman Kodak Co., and upon "Photography," Beeson and Williams.

DIAPHRAGMS OR STOPS.

4. The negative record of the image formed by the lens on a photographic film or plate is produced by the chemical action of light, and for any one kind of plate or film requires a very definite amount of it. It follows, then, that time of exposure can be less as the camera opening is increased or as the plate is moved closer to the lens. It also follows that the time of exposure can be less on a bright day than it could be on a cloudy day.

5. Most photographic lenses are fitted with metallic diaphragms which serve to control the amount of light passing through the lens. The size of this opening is usually expressed in terms of the focal length of the lens and is usually abbreviated as F. Thus F/8 means a stop or hole of a diameter equal to 1/8 of the distance between the lens and its principal focal plane, but the size of the stop might be anything in inches and depends entirely upon the focal length of the lens. This system of notation is convenient, because under similar conditions a correct exposure for a plate will be secured, whatever the focal length of the lens may be, just so long as a stop of the same proportionate value be used.

6. The reason for this is as follows: The brilliancy of the illumination on the film varies inversely as the square of the distance between the lens and film—that is, if the distance be doubled the illumination is decreased four times. Therefore, a film in the focal plane of an 8-inch lens is illuminated four times as brightly as when placed in the focal plane of a 16-inch lens, if the same size aperture in inches is used. On the other hand, if the stops have the same F. value, matters are balanced, as the long focused lens has twice the diameter of the other, and therefore admits four times the light. This is true because areas of circles vary directly as the square of their dimensions.

7. The standard British stops are:

$$\frac{F}{4}\quad\frac{F}{5.6}\quad\frac{F}{8}\quad\frac{F}{11}\quad\frac{F}{16}\quad\frac{F}{22}\quad\frac{F}{32}\quad\frac{F}{45}\quad\&\quad\frac{F}{64}$$

They are so graded that each passes approximately half the light of that next above it on the scale.

8. To find the relative exposure required with the various sizes of stops on a lens, compare the squares of the denominators, which for the first seven values named above are respectively 16, 31½, 64, 121, 256, 484, 1024; or, reducing the first to unity, 1, 2, 4, 8, 16, 32, 64 (approximately). Example: The correct exposure with F/5.6 is 8 seconds; what will it be with F/32? The value of F/32 is to that of F/5.6 as 64 is to 2, so the answer is $8 \times \frac{64}{2} = 256$ seconds.

9. Most American camera stops are numbered 1, 2, 4, 8, 16, 32, 64, the numerals representing the number of times that the exposure needed for the largest must be multiplied. Thus, if stop No. 32 be used, and two seconds is the exposure required for No. 1, the time to be given is 32 by 2, or 64. This is the system employed upon the autotime scale of the 3A camera.

10. *Auxiliary uses of stops.*—Besides serving to control the intensity of illumination, the stop has the following additional functions:

(1) It keeps out rays that fall so obliquely on the lens, that if allowed to pass they would come to a focus nearer the lens than do the rays which strike the lens less obliquely.

(2) It increases the depth of focus. The difficulty of focusing objects in different planes increases with the proximity of the planes to the camera. By decreasing the size of the stop we can, as it were, pull all the planes together and get a sharp focus, even if one object is quite close and another a long way off. There are many occasions on which the photographer will find this property most valuable.

(3) It extends the area of sharp definition given by the lens. Thus, a lens which with its diaphragm full open may barely cover a quarterplate sharply, yet if stopped down may cover a half plate.

(4) It equalizes illumination all over the plate. With a large stop the center of the picture may be much

brighter than the marginal areas. If the size of stop is decreased, the difference between central and marginal illumination is decreased also.

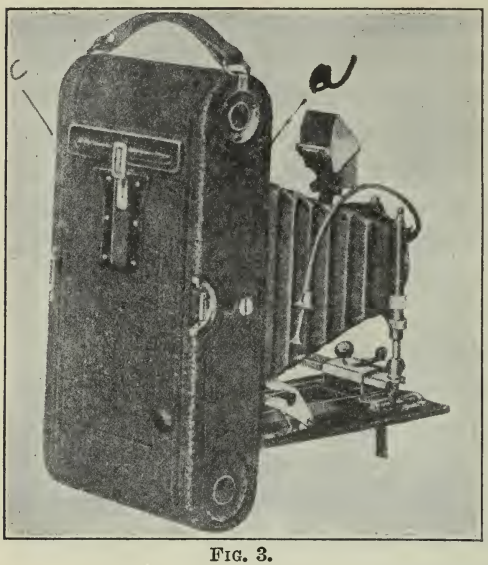


FIG. 3.

(5) It partly remedies the effect of curvature of field, which tends to make the focal plane saucer-shaped.

II. THE 3A AUTOGRAPHIC CAMERA.

DESCRIPTION.

12. Figures 3 and 4 show the 3A Autographic Camera as furnished to Engineer companies. It will be noted that it is equipped with cable release, the autographic feature, automatic shutter, and autotime scales. The camera is opened by pressing the concealed button "a," pulling the front board down, pressing the two clamps "b" together, and pulling the front out so as to extend the bellows. The camera may be used in either the vertical or horizontal positions by turning the finder 90° about a hinge provided for that purpose. It is also equipped with rising and sliding front.

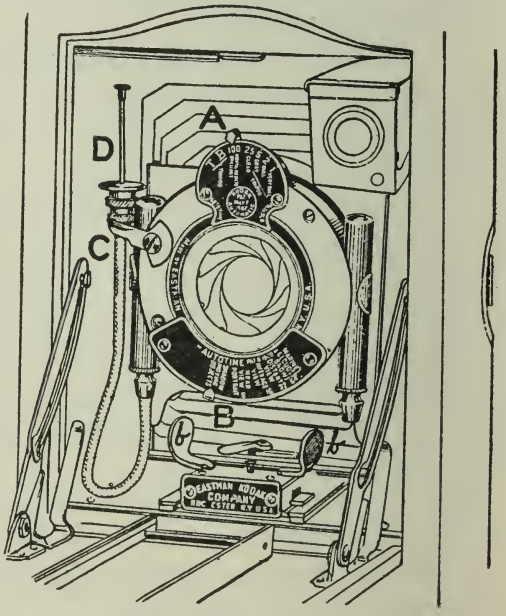


FIG. 4.

13. *The autographic feature.*—The camera has a spring door "c" at the back which covers a narrow slot through

which writing is done upon the red paper protecting the film. This slot has an automatic safety spring border which operates when the door is open to press the papers into contact with the back of the film, thus securing sharp printing of the image and preventing diffusion of light around the edges of the slot. The slot is so located that the writing normally comes between exposures. A stylus or smooth-pointed pencil should be used in a vertical position, care being taken to press firmly on both the up and down strokes. After finishing the writing, the door should be left open for printing, in accordance with the following table, exposing the door to the sky but not to the direct rays of the sun.

	Out of doors.	Indoor, close to window.
Brilliant light	2 to 5 seconds	5 to 7 seconds.
Dull light	5 to 10 seconds	10 to 15 seconds.

Incandescent light, distance 2 inches, 30 to 60 seconds.
Welsbach light, distance 6 inches, 30 to 60 seconds.

14. *Important.*—When the last exposure (No. 6 or 10) has been made and the separate autographic records have been made in accordance with the foregoing directions, turn the winding key of the Kodak until the letter A appears in the center of the window. Then raise the spring door and insert any notes descriptive of the entire roll. Next close the spring door and finish winding the film and unload.

15. *The automatic shutter.*—The indicator A should be moved to the point indicating the kind of exposure desired and the exposure made by pressing the lever or the pushpin at the end of the cable release D. When the indicator is at T the pushpin or lever must be pressed to open the shutter and again to close it. When at B the shutter closes the instant the pressure is released. Both permit exposures to be timed by a watch. (Care must be taken while making time exposures not to jar the camera when manipulating the shutter. When the indicator is set at any of the numbers 1 to 100, speeds ranging between one

and one hundredth of a second result. The cable release is then pushed but once for the exposure.)

(*Caution.*—Do not oil any part of the shutter.)

16. *The autotime scales.*—The autotime scales furnished with this camera greatly simplify the work of computing the time of exposure and the stop to be used under varying conditions.

The following is a summary of the settings for different conditions:

(1) The indicator should be set at 100 for all rapidly moving objects.

(2) The only time when the camera can be held in the hand when taking pictures is when the indicator is set either at 100 or at 25; even then great care must be taken not to move the camera at the instant that the shutter is manipulated.

(3) Settings of upper scale for various kinds of light.

"Brilliant": Use only when sunshine is clear and intense and is shining directly on the principal parts of the picture.

"Clear": This is used for ordinary sunshine; and for intense sunshine not falling directly on the principal parts of the picture or when part of the subject is in shadow.

"Gray": Hazy or dull sunshine, best judged by the shadow cast by the sun which would be called "half shadow," a distinct shadow, but not as strong as with "brilliant" or "clear".

"Dull": Where a faint shadow is barely visible.

"Very dull": Sky completely overcast; no shadow of any kind visible.

(4) Setting of the lower scale (stops or diaphragms), with reference to subject and light.

The markings on this scale are for summer at midday. During the winter or for the morning or afternoon use the next larger aperture than that indicated.

"64," "Marine, clouds, snow": Use this division where any one of these is the principal subject in the pic-

ture. Marine—when view is nearly all water, as with ships or yachts at a long distance. Exception: Marine or distant views may be taken with open lens and instantaneous when conditions require it, such as from decks of moving vessels when the light is poor. Snow—Use for distant snow scenes only. Clouds—This refers to no other subject.

" 32," " Distant view ": For landscapes, mountain views, etc., where the whole view is removed some distance, or, in other words, a general view, without a principal object in the foreground.

" 16," "Average view ": A general landscape with a principal object in the foreground, the general landscape being in the nature of a background to the principal object. The camera is always set at 100 feet, but the subject in the foreground may be as close to the camera as 22 feet.

" 8," " Near-view portrait ": Portraits themselves, and all other views where the camera is focused at less than 100 feet, are classed as general portraiture.

(*Caution.*—When the sun is shining and the subject is under cover or trees, so that no sky is visible overhead, set the lower pointer at " shadow " and use " clear " for time.)

" 4," " Shadow ". Use for all near views where the principal object does not receive the direct light of the sun or sky. Use also for near objects of general red, green, brown, or black color. " Moving objects "—Use for all moving objects. Rapidly moving objects require the use of " brilliant " and "shadow." Ordinary moving objects, such as people walking, street traffic, etc., can be taken with " brilliant " or " clear."

In case it is desired to cut down the aperture in order to gain the full depth of the focus of the lens, it is only necessary to move the speed pointer the same number of divisions toward " Very dull " as you move the aperture pointer toward the smaller opening. You will then secure the same resultant exposure, with the increased

definition desired. The reverse of this is also true, and by this means any aperture or any speed can be used within the limits of proper exposure.

5. Settings of the lower scale, with reference to the kind of exposure.

No. 4: For instantaneous exposures on slightly cloudy days.

No. 8: For all ordinary instantaneous exposures when the sun shines.

No. 16: For instantaneous exposures when the sunlight is unusually strong and there are no heavy shadows; such as in views on the seashore or on the water; also for some interior time exposures.

Nos. "32," "64": For interiors; never for instantaneous exposures.

17. *Rising and sliding front.*—The No. 3A Autographic Kodaks are provided with a rising front, which may be utilized in cutting out an undesirable foreground. The front will also slide to either the right or left (up and down when used for horizontal pictures). The front may be raised or lowered by pressing in on an eccentric catch just below the milled elevating screw, and at the same time turning this to right or left. When through using, center lens by moving the front up and down as the case may be, until the eccentric catch locates itself in notch in standard.

18. The front can be moved to the right or left (up and down when Kodak is placed on its side for a horizontal exposure) by first releasing lever and then pressing down on spring catch directly under the lever, and at the same time sliding front in either direction to the desired position. When through using, reverse the operation and slide back to the center when the spring catch will hold front in position. Then turn lever to hold front rigid.

19. In order to make a sharp picture when using the rising front it will be better to use a small stop (No. 32 or 64), and as this in turn necessitates a time exposure a tripod or other firm support must be provided. Experi-

ence alone can teach the many ways in which the rising and sliding front may be used for composing artistic pictures.

N. B.—Do not fail to center front before closing camera, as otherwise there is danger of ruining the bellows during folding.

B. DIRECTIONS FOR OPERATING THE 3A AUTOGRAPHIC CAMERA.

20. (*a*) *Loading.*—The autographic film cartridge is made with a thin red instead of the familiar thick red and black (duplex) paper. The thin red paper is not light proof in itself. Between it and the film is inserted a strip of tissue which serves two purposes—to supplement the red paper in light proofing the cartridge and to permit the recording, by light, of the writing upon the film. It should be borne in mind that after the seal is broken care must be taken to keep the red paper taut on the spool, as otherwise it may slip and loosen sufficiently to admit enough light to fog the film.

(1) Take a position at a table or at some similar support where the daylight is subdued. Remove the back of the camera by pressing in simultaneously on the two catches opposite its middle.

(2) Pull out the spool pins at both ends of the camera, removing the exposed roll, and transfer the empty spool to the winding end. Then drop the film cartridge into the other recess and manipulate it so that the spool pins may be readily pressed into place. Care must be taken to get the top of the cartridge (plainly marked "top") at the top of the camera. (The top of the camera is its winding side.)

(3) Remove the gummed slip that holds the end of the red paper; pass paper over the two aluminum rollers and into the roll slit. Care must be taken in doing this so that the paper will draw straight and true. Next give the key one or two turns, just enough to bend the paper upon the reel.

(4) Replace the camera back, being careful to put it on right side up, remembering that the wide catch is at

the top. Snap the springs at the top and bottom full into place. The camera back must be handled carefully when detached, as the slightest bend will make it fit badly and may result in leakage of light.

(5) As stated previously, the roller of film is covered with red paper. This must be rolled off before a picture can be taken, turning the key slightly to the left and watching the little celluloid window at the back of the camera. When about 15 turns have been given, a hand pointing to the first number will appear. Turn slowly then until the figure 1 registers with the window. The film is now in a position for taking a picture.

21. (*b*) *Focusing.*—(1) Press the concealed button and push down the bed of camera to the limit of motion.

54. (2) Set the locking device for the distance desired, grasp the springs at the bottom of the front board and pull out the front to the limit.

22. NOTE.—The index plate is scaled both by feet and by meters and care should be taken not to confuse them. Except when photographing at a distance of 15 feet or less, it is not necessary to estimate the distance with any more than approximate accuracy; for instance, if the focus is set at 25 feet (the usual distance for ordinary street work) the sharpest part of the picture will be the objects at that distance from the camera, but everything from 15 to 35 feet will be in good focus. For general street work the focus may be kept at 25 feet, but where the principal object is nearer or farther away, the focus should be changed accordingly. The index plate is divided for 6, 8, 10, 12, 15, 25, 50, and 100 feet. Everything beyond 100 feet is in the 100-foot focus. Nothing nearer than 6 feet can be focused without using the portrait attachment.

(3) Aim the camera at the object to be photographed and locate the image in the finder. For a horizontal picture hold the camera as shown in figure 5, reversing the finder, as indicated. Always look into the finder directly over it, not at an angle. (If a ground focusing glass is employed the image will be located on that instead of in the finder.)

58. (4) For a vertical exposure the camera must be held as shown in Fig. 6. The finders give the scope of view and show a facsimile of the picture as it will appear, but on a reduced scale. Any object that does not show in the finder will not show in the picture.

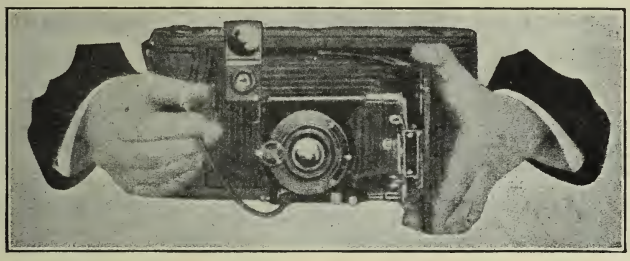


FIG. 5.

23. (*c*) *Exposing the film.*—Before making an exposure with the No. 3A Autographic Kodak, either time or instantaneous, be sure of four things:

First. That the shutter is set properly.

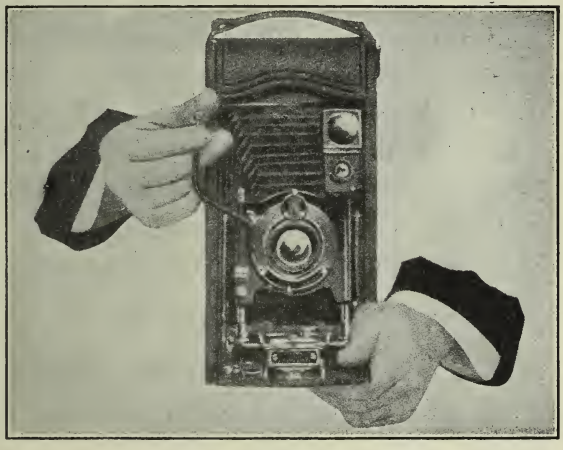


FIG. 6.

Second. That the diaphragm stop is set at the proper opening.

Third. That the camera is focused.

Fourth. That an unexposed section of the film is turned into position.

24. (*d*) *Removing exposed films.*—(1) When the last section of film has been exposed, give the key about five

half turns. Take a position as far as possible from a window, and remove the back of the camera as previously described.

(2) Holding the red paper taut so as to wind tightly, turn the key until all of the paper in on the reel. Take care to hold the ends of the red paper and sticker together so as to prevent the paper from loosening on the reel.

(3) Pull out spool pin and winding key and remove roll.

(4) Fold over half inch at end of red paper (so as to make subsequent breaking of seal easy) and then seal with sticker.

(5) Wrap up exposed film at once so as to prevent possibility of light being admitted.

(6) Transfer the empty spool to the winding side of the camera and reload as previously described.

INSTANTANEOUS EXPOSURES.

25. The object must be in the broad open sunlight but the camera should not be. The sun should be behind the back or over the shoulder of the operator. For all ordinary out-door work when the sun is very bright, use stop No. F/11. If a smaller stop be used, the light will be so much reduced that it will not sufficiently impress the image on the film and failure will result.

26. No. 16 may be used for marine views with unusually strong sunlight.

TIME EXPOSURES.

27. (*a*) *Interiors.*—(1) Place the camera on some firm support and so that the finder will embrace the view desired. It should not be pointed directly at a window, as the glare will blur the picture. If all the windows can not be avoided, pull down the shades of such as come within the range of view.

(2) Set the shutter at T and the stop at the proper point. Press the push pin once to open and again to close the shutter. Time the exposure with a watch.

(3) After making the autographic record, turn a new film into position.

(4) Time required for interior exposures.

28. The following table gives the time of exposure required under varying conditions of light with the stop No. 16 in the lens. This means that with No. 8 stop the time of exposure is cut in half, and with 128 should be multiplied by 8. It should be borne in mind that the smaller the stop the sharper the picture. As a rule No. 16 will give best results for interiors.

White walls and more than one window:
- Bright sun outside, 4 seconds.
- Hazy sun, 10 seconds.
- Cloudy bright, 20 seconds.
- Cloudy dull, 40 seconds.

White walls and only one window:
- Bright sun outside, 6 seconds.
- Hazy sun, 15 seconds.
- Cloudy bright, 30 seconds.
- Cloudy dull, 60 seconds.

Medium colored walls and hangings and more than one window:
- Bright sun outside, 8 seconds.
- Hazy sun, 20 seconds.
- Cloudy bright, 40 seconds.
- Cloudy dull, 80 seconds.

Medium colored walls and hangings and only one window:
- Bright sun outside, 12 seconds.
- Hazy sun, 30 seconds.
- Cloudy bright, 60 seconds.
- Cloudy dull, 120 seconds.

Dark colored walls and hangings and more than one window:
- Bright sun outside, 20 seconds.
- Hazy sun, 40 seconds.
- Cloudy bright, 80 seconds.
- Cloudy dull, 2 minutes, 40 seconds.

Dark colored walls and hangings and only one window:
- Bright sun outside, 40 seconds.
- Hazy sun, 80 seconds.
- Cloudy bright, 2 minutes, 40 seconds.
- Cloudy dull, 5 minutes, 20 seconds.

29. The foregoing is calculated for rooms whose windows get the direct light from the sky, and for hours from 3 hours after sunrise until 3 hours before sunset.

30. If earlier or later, the time should be increased.

31. (*b*) *Time exposures in the open air.*—When the stop No. 128 or F/45 is in the lens, the light admitted is so much reduced that time exposures may be made out of doors the same as interiors. The exposure, however, must

be much shorter and should be made with the shutter indicator set at "B."

With sunshine, $\frac{1}{5}$ second.
With light clouds, from $\frac{1}{2}$ to 1 second will be sufficient.
With heavy clouds, from 2 to 5 seconds will be required.

32. The above is calculated for the same hours as mentioned for interiors and for objects in the open air. For other hours or for objects in the shadow, under porches or under trees, no accurate directions can be given; experience only can teach the proper exposures.

33. Time exposures can not be made while the kodak is held in the hand. Always place it upon some firm support, such as a tripod, chair, or table.

SOME CAMERA TROUBLES AND HOW TO ELIMINATE THEM.

34. (*a*) *Dimmed finders and how to make them bright again.*—For causes not always thoroughly understood, glass will sometimes "sweat" to such an extent as to cover itself with a film, which will decrease the amount of light passing through it or reflected from it. Whatever the cause the result is the occasional dimming of finders and lenses. With finders the trouble is sometimes in the mirror, which necessitates opening the finder and wiping the mirror with a soft cotton cloth. The brilliant finders of the No. 3A Autographic Kodaks can readily be cleaned by lifting up front and swinging back top. After cleaning as above close, by simply snapping back into position.

35. (*b*) *Cleaning lenses.*—Lenses should be frequently examined by looking through them, and if found to be dirty, should be wiped both front and back with a clean, soft linen handkerchief. Large spots of dust or dirt on the lens will cause defects in the picture, while if the lens is evenly covered with a film of dust, dirt, or moisture, the effect will be to cut off a great deal of light and make the picture undertimed.

36. (*c*) *Keep dust out of the camera.*—Defective negatives are often caused by particles of dust which have collected on the inside of the camera and settle upon the film in particles that produce small dark spots upon the prints.

III. THE 3A GRAFLEX CAMERA.

DESCRIPTION.

37. Practically all that has been said with reference to lenses, stops, time of exposure, etc., in connection with the 3A Autographic camera is equally applicable to the 3A Graflex camera.

38. This camera differs from the former: First, in that it is equipped with a finder which, when viewed from above, shows an image reflected from a mirror set at an angle of 45° to the axis of the finder lens. The great advantage of this camera is that it is focused when the finder is focused. The cross section of the camera below shows the position of the mirror when set for focusing as well as the focal plane shutter, which operates just in front of the film. This shutter is actuated by a spring and has different sized slits so that varying amounts of light reach the film, depending upon the width of the slit used.

39. The paths of the rays A and B through the lens to the mirror and thence to the focusing screen are indicated in Fig. 7. It will be noted that the image is erect. When the mirror is released, an instant before the exposure, the rays pass directly through the shutter slit to the film as at A2 and B2.

DIRECTIONS FOR OPERATING THE 3A GRAFLEX CAMERA.

40. (*a*) *Loading the camera.*—The back panel of camera is hinged, and may be opened by releasing sliding lock. To load, the bracket carrying the spool at left end of camera is drawn forward until the hinged end springs open. This permits the spool to be set in between the centers and the bracket pressed back into the film pocket, securely holding the spool between the centers. The black paper is drawn across the focal plane and threaded into the receiving spool, which drops into position without the use of centers, journaling against the metal guide at one end and centering on the winding key at the other. When the back panel is closed, two light pressure bars, fastened to the face of this panel, press the film forward to a

true focal plane. The film is wound off until the number of each exposure registers at the small ruby window. Two small pockets at either end of camera, opening with spring catched door, carry two extra rolls of film.

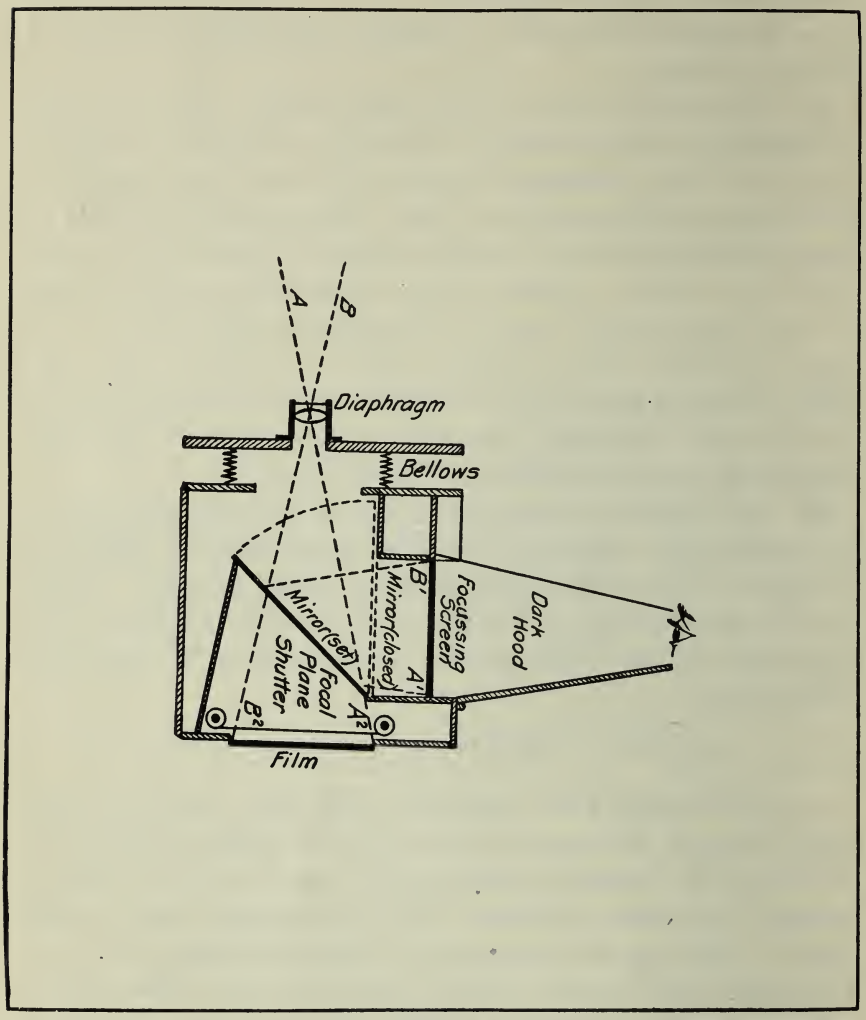


Fig. 7.

41. (*b*) *Focusing.*—Adjust the focusing hood by releasing catch near center of camera. Raise the cover, which automatically extends the focusing hood. Press down the two side arms, which will draw the focusing hood taut, and hold it in this position. Open front of the camera by pressing release button on right upper forward

corner, draw out lens front to desired position, and adjust fine focus with rack and pinion.

42. (*c*) *Setting the mirror.*—Press lever H down until it catches.

43. (*d*) *To set shutter for instantaneous work.*—Push lever H down until it locks, which sets the mirror. Depress disk D, which surrounds the shaft of lever H, and revolve it until letter I stands directly opposite the white mark on lever H, indicating instantaneous exposures.

44. (*e*) *To set curtain.*—Wind the curtain by turning key A toward the left until the desired aperture appears at F. The Graflex curtain is made in one long piece, containing five apertures as follows: Full opening for time work, 1-1/2 inch, 3/4 inch, 3/8 inch, and 1/8 inch for instantaneous exposures. Any of the smaller instantaneous exposing apertures may be brought into position by turning key A to the left, running in rotation from the larger to the smaller apertures or the curtain may be lowered from the smaller to the larger apertures by pressing on lever M directly above winding key. When letter O shows on the aperture index at F the curtain is wide open, and by setting the curtain aperture at O and releasing the mirror for instantaneous work, a slow instantaneous exposure can be made, giving practically a flap and drop effect.

45. (*f*) *For time exposures.*—Depress disk D and revolve until letter T stands opposite the white mark on lever H. Wind the curtain until letter T shows at aperture. Set the mirror in the usual manner. After focusing release the mirror, which travels up out of the cone of light. Open the exposure by pressing lever M and terminate the exposure by a second pressure on lever M.

46. (*g*) *For instantaneous exposures.*—To make an instantaneous exposure when the object to be photographed is focused sharply upon the focusing screen, a downward pressure on lever E, near the front on left hand side of camera, releases the mirror, which travels up out of the cone of light, automatically releasing the shutter, and as

the action of these is simultaneous the object, although moving broadside to the camera, can be located perfectly in the center of film.

47. (*h*) *Caution.*—A safety lock prevents the curtain being rewound before the mirror is set when making instantaneous exposures. This prevents fogging the film, making it necessary to set the mirror before rewinding the shutter.

48. (*i*) *To regulate rate of speed.*—Turn milled head to the left until tension number desired appears at G. The numbers run from 1 to 6, the highest number indicating the greatest speed.

49. (*j*) *To lower tension.*—Release spring by pushing escapement P back and forth, as the tension may be lowered from the highest to the lowest number, stopping at any intermediate number or between numbers.

50. The table on back of focusing hood gives approximate degrees of speeds in fractional parts of seconds obtainable with the tension numbers from 1 to 6, and the various curtain apertures. However, the tension can be set at intermediate points, giving a greater variation of speeds than shown by this table.

51. The following tables will be found useful:

TABLE I.

When height of image of man or horse is 1½ inches on ground glass, the distance will be about, for a—	Feet.
5-inch lens	20
6-inch lens	25
7-inch lens	30
8-inch lens	33
10-inch lens	40
12-inch lens	50
14-inch lens	60

And shutter speed must be at least—

When height of image of man or horse is ¾ inch on ground glass the distance will be about, for a—	Feet.
5-inch lens	40
6-inch lens	50
7-inch lens	60
8-inch lens	66
10-inch lens	80
12-inch lens	100
14-inch lens	120

And shutter speed must be at least—

Subject.	Figure moving at right angles to camera.	At 45°.	Figure moving toward camera.	Figure moving at right angles to camera.	At 45°.	Figure moving toward camera.
100-yard race	1–655	1–490	1–270	1–330	1–270	1–130
½-mile race	1–655	1–330	1–215	1–330	1–215	1–105
1-mile race	1–655	1–330	1–215	1–330	1–215	1–105
Swift skater	1–1, 000	1–655	1–330	1–490	1–330	1–175
Man walking rapidly	1–160	1–105	1–50	1–75	1–50	1–25
Horse walking rapidly	1–160	1–105	1–50	1–75	1–50	1–25
Bicycle, ordinary pace	1–330	1–215	1–105	1–160	1–105	1–50
Bicycle racing	1–655	1–490	1–215	1–330	1–215	1–105
Fast horse trotting	1–1, 000	1–655	1–330	1–490	1–330	1–175
Horse galloping	1–1, 200	1–825	1–490	1–655	1–490	1–215
Horse jumping	1–1, 200	1–825	1–490	1–655	1–490	1–215
Train or automobile, 35 miles an hour, distance 100 feet				1–330	1–215	1–105
Train or automobile, 60 miles an hour, distance 100 feet				1–655	1–490	1–215

52. The following subjects need not be specially rated, as all of them may be taken with a speed of $\frac{1}{160}$ second or less. Man walking slowly, $\frac{1}{50}$; street scenes, $\frac{1}{50}$; cattle grazing, $\frac{1}{50}$; boating, $\frac{1}{60}$; and all slow-moving subjects.

53.

TABLE II.—*7-inch equivalent focus lens.*

DISTANCE FROM OBJECT.

Stop.	15 feet.	18 feet.	24 feet.	30 feet.
	Depth of field of focus.	Depth of field of focus.	Depth of field of focus.	Depth of field of focus.
	Inches.	*Inches.*	*Inches.*	*Inches.*
F–5 or U. S. 1.56	31	45	80	126
F–6.3 or U. S. 2.50	40	58	102	161
F–8 or U. S. 4	51	74	132	211
F–11 or U. S. 8	71	103	189	311

IV. DEVELOPING.

DEVELOPERS.

54. (*a*) *General.*—In the field, where a dark room is rarely, if ever, available, recourse must be had to the Kodak film tank for development. If used in accordance with instructions and with the prepared developers furnished, it gives very good results. There are a few cases, however, where a skilled photographer can obtain better results from hand development and by mixing his own developers; hence the following formulæ. At least 15 different chemicals are good developing agents.

Among them are:

Pyrogallic acid ("Pyro").
Hydroquinone or hydrokinone.
Metol.
Amidol.
Rodinal.
Glycin.
Ortol.
Syntol.
Eikonogen.
Diogen.
Edinol.
Diamidophenol.

55. All give much the same final results, but they vary greatly as regards the manner and time in which they effect complete development.

56. Each constituent of a developer has its own function to perform; as follows:

(1) *The actual developing salt or reducing agent.*—Pyro, metol, hydroquinone, etc.

(2) *Sodium sulphite.*—In the case of pyro it acts partly as a preservative, but more particularly as an antistain. With some other salts it also serves as an accelerator.

(3) *The accelerator.*—In practice always an alkali. Sodium carbonate is most widely used. Half the quantity of potassium carbonate may be substituted. As its name implies, this constituent hastens development. An excess of accelerator tends to cause fogging.

(4) *The restrainer, bromide of potassium.*—This retards the action of the developer and helps to prevent fogging. If added at the commencement of development it will, within limits, correct overexposure by holding back the shadows and giving the high lights and half tones a start.

(5) *The preservative.*—Pyro stock developer requires the addition of a preservative, either nitric, citric, or sulphuric acid, or potassium metabisulphite. The last named is best.

57. (*b*) *Dark-room developers.*—Any good developer may be used with any good plate or film. Pyro is popular, as it is cheap, quick acting, and easily controlled by varying the proportions of its constituents. The following two-solution pyro developer is a good, clean working developer:

PYRO SODA DEVELOPER.

58. Solution No. 1. Label "No. 1 Pyro."

Sodium sulphite	3 ounces.
Potassium metabisulphite	2½ drams.
Pyro	160 grains.
Water to make 20 oz.	
Dissolve in the order given.	

59. Solution No. 2. Label "No. 2 Sod. Carb."

Sodium carbonate	4 oz.
Water to make 20 oz.	

60. For use take one part of No. 1, one part No. 2, two parts water. These proportions give soft negatives suitable for enlarging, after from four to six minutes' develop-

ment at normal temperatures (60° to 65° F.). If more contrast is desired take equal parts of No. 1, No. 2, and water.

METOL-HYDROQUINONE DEVELOPER.

61. The following is a nonstaining developer suitable for plates and bromide prints:

62. " A " solution:

Metol	½ dram.
Hydroquinone	1 dram.
Potassium metabisulphite	½ dram.
Water to make 20 oz.	

63. " B " solution:

Sodium carbonate	1 oz.
Sodium sulphite	1 oz.
Water to make 20 oz.	
For use take equal parts of "A" and " B."	

64. (*c*) *Tank developers.*—In addition to the prepared developers the following formula has been carefully tested and is thoroughly reliable:

PYRO TANK DEVELOPER.

STOCK SOLUTION.

Metol	60 grains.
Hydrochinon	240 grains.
Sodium sulphite (dry)	540 grains.
Sodium carbonate (dry)	1,500 grains.
Potassium bromide	30 grains.
Water	50 ounces.

FOR HAND DEVELOPMENT USE.

Stock solution	4 ounces.
Dry pyro	5 grains.
Water	6 ounces.

FOR TANK DEVEOPMENT USE.

Stock solution	10 ounces.
Dry Pyro	15 grains.
Water	40 ounces.
Develop 10 minutes at 68° F.	

GLYCIN TANK DEVELOPER.

STOCK SOLUTION.

Hot water (about 200°)	50 ounces.
Carbonate soda (dry)*	2 ounces.
Glycin	½ ounce.
Sulphite soda (dry)*	½ ounce.
Dissolve in order stated.	

* If crystal sodas are used, double the quantity.

65. For 10-minute development, use five ounces stock solution to thirty ounces water. Temperature, 65°. For 25-minute development, use two ounces stock solution to thirty-two ounces water. Temperature, 65°.

THE FILM TANK.

66. The Kodak film tank consists of a wooden box, a light-proof apron, a "transferring reel," a metal "solution cup," in which the film is developed, and a hooked rod for removing film from solution. There is also a dummy film cartridge with which one should experiment before using an exposed cartridge. The various parts of the outfit come packed in the box itself.

67. (*a*) *Preparing the cartridge.*—Film to be used in the Kodak film tank must be fastened to the black paper at both ends. All films are fastened at one end at the factory. The other end is fastened as follows: Just before you are ready to develop (holding spool with the unprinted side of the black paper up) unroll the black paper carefully until you uncover the piece of gummed paper which is fastened to end of film and is to be used as a means of fastening film to black paper. Moisten the gummed side of sticker evenly for about an inch across the end and stick it down to black paper, rubbing thoroughly to secure perfect adhesion. Wind end of black paper on spool again, and the cartridge is ready to insert in machine.

68. (*b*) *Setting up the film tank.*—Take everything out of the box. Take the apron and transferring reel out of solution cup.

69. The axles marked C and D in the cut are to be inserted in the holes in the front of box. The front will be toward you when the spool carrier in end of box is at your right. These axles are interchangeable. The axle C must be pushed through the hollow spindle which will be found loose in the box. This spindle has a lug at each end to which the hooks of the apron are to be attached.

70. The axle D must be pushed through the hollow rod of the transferring reel to hold reel in position as indicated in the illustration. The flanges at each end of the transferring reel are marked Y in the illustration. Both axles C and D must be pushed clear through into the holes on the opposite side of the box.

71. Attach one end of the apron to spindle, through which axle C passes, by means of the metal hooks which are to be engaged with the lugs on the spindle. The corrugated side of the rubber bands is to be beneath the apron when it is attached. Turn to left on axle C and wind entire apron on to axle, maintaining a slight tension on apron in so doing by resting one hand on it.

72. (*c*) *Operating the film tank.*—Insert film cartridge in spool carrier, and close up the movable arm tight against end of spool; have the black paper lead from the top.

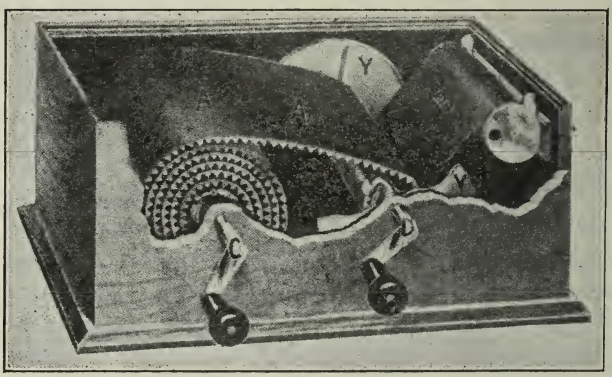


FIG. 8.

73. Thread the paper underneath wire guard on transferring reel, through which axle D passes, and turn axle slowly to right until the word "stop" appears on black paper.

74. Now hook apron to lugs on transferring reel in precisely the same manner that you hooked the opposite end to lugs on the spindle, except that axle D turns to the right.

75. Turn handle half a revolution so that apron becomes firmly attached and put on cover of box. Turn axle D slowly and steadily until black paper, film and apron are rolled up together on reel. As soon as this is competed the handle will turn very freely.

76. Prepare developer as described below.

77. Now remove cover from box and draw out axle D, holding apron and black paper with other hand to keep end of apron from loosening.

78. Remove entire transferring reel (now containing apron, black paper, and film), which is freed by pulling out axle D, and insert immediately in the previously prepared developer. In removing reel do not squeeze the apron, but hold it loosely or slip a rubber band about it to keep from unrolling.

78. (*d*) *Using the solution cup.*—Having filled solution cup as directed hereafter, lower transferring reel into cup, with the end containing crossbar up. Let reel slide down slowly. The operation of removing reel from box can be done in the light of an ordinary room, but for safety it is well that the light should not be too bright. The total length of time for development is 20 minutes. Then place the cover on the cup, putting lugs on cover into the grooves, and tighten cover down by turning it to right. Now turn the entire cup end for end and place in a tray or saucer to catch any slight leak from the cup.

79. At the end of 3 minutes again reverse the cup, and thereafter reverse every 3 minutes until the time of development (20 minutes) has elapsed.

80. Turning the solution cup in this manner allows the developer to act evenly and adds brilliancy and snap to the negatives.

81. The wire hook is to be used for lifting the reel out of the cup. Hook on to the crossbar in one end of reel.

82. Immediately after lowering reel into solution cup catch it with wire hook and move slowly up and down two or three times, taking care, however, not to raise any part of reel above the surface of solution. This is to expel air bubbles.

83. When development is completed pour out developer and fill cup with clear, cold water and pour off, repeating this operation three times to wash the film. Then remove transferring reel; separate film from black paper and place immediately in the fixing bath, which should be in readiness, prepared in accordance with directions. (See p. 47.)

84. The film may be separated from black paper in light of an ordinary room if the developer is thoroughly washed out.

85. The operation of separating film and black paper should be done over a bowl or bathtub or sink.

86. When the black paper does not free itself readily from back of film split the paper where possible; this will remove the hard outer surface of the paper; the remaining portion will soon become soaked and can then be removed easily by rubbing gently, while immersed, with the ball of the finger. This adhering of the black paper to the film is almost invariably caused by the use of a too warm developer.

87. After developing a roll of film the apron must be wiped dry before developing another roll. The apron will dry almost instantly if immersed for a moment in very hot water.

88. Keep apron wound on axle D when not in use. Never leave apron soaking in water.

89. (*e*) *Preparing the developer.*—The kodak tank developer powders are prepared especially for use with Eastman films and the kodak film tank.

90. Put 4 or 5 ounces of lukewarm water into the solution cup, and dissolve in it the contents of the large package. Fill the cup with cold water to the embossed ring—not to the top. Now dissolve the contents of the small package in this solution and the developer will be ready. The temperature of the developer should be 65° F.

91. If some of the contents of the small package stick to the paper, dip the paper into the solution to remove.

92. The developer must always be mixed fresh and used for only one roll of film.

93. (*f*) *Short development.*—If it is desired to shorten the length of development, equally good results may be obtained by using two pairs of the powders and developing for 10 minutes.

94. (*g*) *Developer formulas.*—Those who wish to prepare their own developer may do so, but care must be exercised in securing absolutely pure chemicals and correct weights.

FOR 20-MINUTE DEVELOPMENT—3¼-INCH TANK.

22 grains pyro.
66 grains sulphite of soda, desiccated.[1]
44 grains carbonate of soda, desiccated.[1]

[1] If crystals are used, double the quantity.

95. Dissolve the chemicals, in order named, in five or six ounces of lukewarm water, then add cold water to fill tank to embossed ring.

FOR 10-MINUTE DEVELOPMENT—3¼-INCH TANK.

44 grains pyro.
132 grains sulphite of soda, desiccated.[1]
88 grains carbonate of soda, desiccated.[1]

96. Dissolve the chemicals, in order named, in five or six ounces of lukewarm water, then add cold water to fill tank to embossed ring.

97. (*h*) *Time and temperature for tank development.*—It sometimes happens that the amateur is not able to obtain or maintain the standard or normal temperature of 65° F. when using the Kodak tank and the Kodak tank developer powders. In such cases the following table will be found of value:

Temperature.	Time-one powder.	Time-two powders.
Degrees.	*Minutes.*	*Minutes.*
70	15	8
69	16	.....
68	17	9
67	18	.....
66	19	.....
[2] 65	[2] 20	[2] 10
64	21	.....
63	22	.....
62	23	11
61	24	.....
60	25	.....
59	26	12
58	27	.....
57	28	.....
56	29	13
55	30	.....
54	31	.....
53	32	14
52	33	.....
51	34	.....
50	35	15
49	36	.....
48	37	.....
47	38	16
46	39	.....
45	40	17

[1] Normal.
[2] If crystals are used, double the quantity.

98. Temperature of developer must not exceed 70° F., as above that point there is danger of the film frilling; 45° F. is the lowest temperature at which the developing powders can be dissolved, and even at this temperature the powder must be finely crushed and added slowly to the water.

99. It is best to use the normal temperature (65°) when possible, as the use of a developer that is colder than normal has a slight tendency to increase the contrast in a negative, while the use of a developer warmer than normal slightly flattens the resulting negatives.

100. (*i*) *Sea water.*—It has been fully demonstrated that sea water may safely be used in compounding the developer and for all the processes of tank development, provided only that the final rinsing is in clean, fresh water.

101. (*j*) *Troubles with negatives.*—Fog is caused (1) by admission of light during development; (2) leakage in the camera or plate holder; (3) reflection of light from the inside of the camera; (4) dust or dew on the lens; (5) overdevelopment. The third cause is the result of using a lens which more than covers the plate. It is obviated by a lens hood or by a blackened card interposed between lens and plate with an opening of such a size as to pass only light which will reach the plate direct from the lens. Fog due to overexposure and overdevelopment can be remedied by reduction if not too pronounced.

102. *Light patches.*—Caused by imperfect flooding, so that the developer does not take hold of all the film at once.

103. *Dark patches.*—May be due to emanations from the camera if the films have been kept in it for a long time. If a partly dried negative is warmed to complete the drying there may also be a darkening of the parts thus dried.

104. *Round transparent spots.*—Caused by air bells on the film which prevented development of the parts so covered. If the surface of the film is wiped over with a pad of wet cotton wool immediately after flooding, any air bells present will be removed.

105. *Pinholes.*—Due to dust on the film during exposure. This is a very common trouble. Plate carriers and camera should be dusted occasionally, especially in dry weather.

106. *Mottling of film.*—Due to not moving the film during development.

107. *Black spots.*—Due (a) to metallic rust in the water. Always let some water run to waste before using the tap for the first time in a day; (b) to pyro dust settling on the plate. Overworked pyro developer is liable to deposit on a negative and produce black spots.

V. THE FIXING BATH.

108. Provide a box of Kodak acid fixing powder, which should be prepared as follows: Remove the cover from the box and pour into the cover enough of the fixing powder to fill the cover level full. Put this into a tray or wash-bowl and add 8 ounces of cold water. When the powder is thoroughly dissolved, add to the solution as much of the acidifier, which you will find in a small box, inside the large one, as will fill the cover of the small box level full. As soon as this has dissolved the fixing bath is ready for use. Any quantity of the bath may be prepared in the above proportions.

109. Pass the film, face down (the face is the dull side), through the fixing solution, holding one end in each hand. Do this three or four times and then place one end of the film in the tray, still face down, and lower the strip into the solution in folds. Gently press the film where the folds occur, not tightly enough to crack it, down into the solution a few times during the course of fixing. This insures the fixing solution reaching every part of the film. Allow the film to remain in the solution two or three minutes after it has cleared or the milky appearance has disappeared. Then remove for washing.

110. Eastman N. C. film must always be fixed in an acid bath. If Kodak acid fixing powders can not be obatined, the following formula may be used if desired:

Water	16 ounces.
Hypo-sulphite of soda	4 ounces.
Sulphite of soda (desiccated)	80 grains.

When fully dissolved, add the following hardener:

Powdered alum	½ ounce.
Citric acid	½ ounce.

111. This bath may be made up at any time in advance and be used so long as it retains its strength, or is not sufficiently discolored by developer carried into it as to stain the negatives.

VI. WASHING.

112. There are several ways of washing film. It may be placed in a washbowl of cold water and left to soak for five minutes each in five changes of cold water, moving it about occasionally to insure this water acting evenly upon it, or it may be given, say, two changes as above and then left for an hour in a bowl with a very gentle stream of water running in and out.

VII. DRYING FILM NEGATIVES.

113. When thoroughly washed, snap a clip on each end of the strip and hang it up to dry, or pin it up. Be sure, however, that it swings clear of the wall, so that there will be no possibility of either side of the film coming in contact with the latter.

114. If the film has been cut up, pin by one corner to the edge of a shelf or hang the negatives on a stretched string by means of a bent pin, running the pin through the corner of film to the head, then hooking it over the string .

VIII. AFTER TREATMENT OF NEGATIVES.

A. OVER-DEVELOPMENT.

115. Caused by leaving the negative too long in the developer, or by using developer too warm. In this case the negative is very strong and intense by transmitted

light and requires a very long time to print. The remedy is to reduce by the following method:

116. First soak negative 20 minutes in water, then immerse in:

REDUCER.

Water	6 ounces.
Hyposulphite soda	½ ounce.
Ferricyanide potassium (saturated solution). Poison	20 drops.

117. Rock tray gently back and forth until negative has been reduced to the desired density, then wash 10 minutes in running water or in four changes of water.

118. Negatives may be reduced locally by applying the above solution to the dense parts with a camel's-hair brush, rinsing off the reducer with clear water frequently to prevent its running onto the parts of the negative that do not require reducing.

119. Should any yellowness or staining appear in the reduced negative, it may be removed by replacing same in the acid fixing bath for a few minutes.

B. UNDER DEVELOPMENT.

120. Caused by removal from the developer too soon.

121. An underdeveloped negative differs from an underexposed one, in that it is apt to be thin and full of detail, instead of harsh and lacking in detail. If the development is carried on as before directed, this defect is not liable to occur.

122. If a mistake has been made in developing and the negative does not appear strong enough (this can be judged only by experience), the negative can be improved by intensification as follows:

123. After fixing and thorough washing, lay the film, while wet, in an empty tray and pour over it sufficient intensifier to fully cover it; allow it to act until the film is all of one even color and then pour the intensifier back into the bottle and wash the film in four or five changes of water for 15 minutes.

124. Intensifier may be purchased already prepared or the amateur may put it up himself, using the following formula.

INTENSIFIER.

No. 1, 75 gr. bichloride of mercury (corrosive sublimate), poison ..... 5 oz. water.
No. 2, 112 gr. iodide of potassium ..... 2½ oz. water.
No. 3, 150 gr. hyposulphite of soda ..... 2½ oz. water.

125. Dissolve separately and combine No. 1 with No. 2, and the resulting mixture with No. 3.

IX. IN THE TROPICS—PRECAUTIONS.

126. Travelers in tropical or semitropical countries will find their films ruined by the excessive dampness unless they make proper provision against it.

127. The only safe method is to put up the film in hermetically sealed tin cans (one spool to a can) and leave them in the cans until ready for use. After exposure they must be promptly developed. There is no use in returning them to the can after exposure, as they are likely to have absorbed sufficient moisture during exposure to ruin them unless they are promptly developed.

128. Kodak cartridges will be packed in sealed tubes on request, at 5 cents each.

X. PRINTING.

A. ARGO PAPER.

LIGHT.

129. The paper can be safely handled 8 feet from the source of light, which may be Welsbach gas light, covered with post office paper; incandescent light, ordinary gas light, kerosene lamp, or very subdued daylight.

PRINTING.

130. Place paper in an ordinary printing frame, the same as with printing-out paper. After the paper is in perfect contact with negative, expose by holding the printing frame close to gas, lamp, or incandescent light, or to subdued daylight. Artificial light is recommended in preference to daylight, because of uniformity, and it being in consequence easier to judge the proper length of time to expose.

TIMING THE EXPOSURE.

131. Time necessary for exposing is regulated by density of negative and strength of light. It takes about the same time with an ordinary gas burner as with an incandescent light; a Welsbach gas light requires only about one-half as much time as the ordinary gas burner, and with a kerosene lamp of moderate strength, at least three times the exposure necessary with a common gas burner is required. If daylight is used, care must be taken not to overexpose, as its action on the paper is much more rapid than the strongest artificial light. Where artificial light is used, keep printing frame in motion during exposure. To secure the correct time of exposure, a trial should be made at a given distance from the light used, and if subsequent exposures are allowed the same time at the same distance from the light, the results can not fail to be absolutely uniform. With negatives of average density, 1 foot from an ordinary gas burner, from one to two minutes' exposure is required.

TO DEVELOP.

132. After exposing, immerse print in developing solution made as per formula. The print will develop rapidly, and should be closely watched. As soon as desired depth is obtained, remove immediately to a tray of clean water, preferably acidified with acetic acid (about two ounces to a gallon of water), in order to stop development and neutralize the alkali adhering to the print; from there direct to fixing solution, mixed as given below:

METOL QUINOL DEVELOPER.

Water	10 ounces.
Metol	7 grains.
Sodium sulphite (dry powder)	120 grains.
Or crystals, double the quantity.	
Hydroquinone	30 grains.
Sodium carbonate (dry powder)	200 grains.
Or crystals, double the quantity.	

133. When mixed, add to the above 15 to 25 drops of a bromide potassium solution composed of:

Bromide of potassium	1 ounce.
Water	10 ounces.

AMIDOL DEVELOPER.

Amidol	20 grains.
Sulphite soda (crystals)	160 grains.
Or dry, in the form of powder, half the amount.	
Water	8 ounces.

134. When mixed, add to above 5 to 10 drops of a bromide of potassium solution composed of:

Bromide of potassium	1 ounce.
Water	10 ounces.

METOL HYDRO ANTIFRICTION DEVELOPER.

Water	16 ounces.
Hydroquinone	80 grains.
Metol	24 grains.
Argo soda	480 grains.

METOL HYDROEDINOL ANTIFRICTION DEVELOPER.

(For very black tones.)

Water	32 ounces.
Hydroquinone	30 grains.
Metol	90 grains.
Edinol	90 grains.
Argo soda	2 ounces.

DEFENDOL DEVELOPER.

Water	8 ounces.
Defendol	60 grains.
Carbonate soda (dry powder)	240 grains.
Or crystals, double the quantity.	

135. Always dissolve defendol before adding carbonate soda.

136. When mixed, add to the above 5 drops bromide potassium solution composed of:

Bromide of potassium	1 ounce.
Water	10 ounces.

137. For Argo gloss and Argo luster the makers of Argo paper recommend antifriction developer. For all other surfaces, on account of simplicity of manipulation, they recommend defendol.

138. Always keep developer ice cold, as it improves the tone, and the image is much easier to control.

FIXING BATH FORMULA.

Water	64 ounces.
Hypo	16 ounces.

Dissolve, then add the following hardening solution:

Water	5 ounces.
Sulphite soda crystals	1 ounce.
Or powdered dry, half as much.	
Commercial acetic acid	3 ounces.
Powdered alum	1 ounce.

This is ready for use as soon as mixed.

FIXING.

139. Allow prints to remain in fixing solution 10 to 20 minutes; then they should be removed to a tray containing clear water.

WASHING.

140. Wash 1 hour in running water, or in 10 or 12 changes of clear water, allowing prints to soak 2 to 3 minutes in each change.

MOUNTING.

141. After prints are washed, they may be mounted on cardboard by following method: Lay prints face down on glass, one on top of the other; squeeze out surplus water; apply a thick starch paste to the back of topmost print; lay print on card and rub down. Sponge face of print with a clean, damp sponge to remove foreign substances and surplus paste from edges. Prints can then be put between blotters, or laid out on a table, face upward, to dry.

NOTES.

142. Prints must be rinsed a few seconds between the developing and fixing solutions in order to keep the hypo free from alkali. This is also an effective method of preventing yellow stains.

143. Developer may be used several times, but fresh developer is always recommended.

144. If print is overtimed, the image will flash up quickly in developer, high lights will be printed through, and there will be a general weak, muddy effect. If undertimed, the resulting print will be harsh and contrasty.

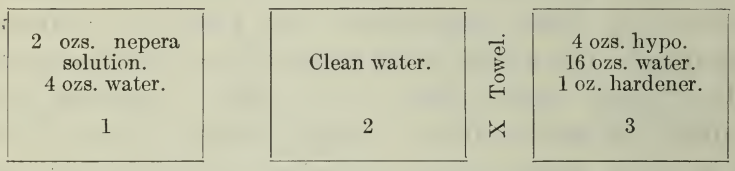
145. Underexposed prints, which have of necessity been forced in development, will not have clear whites, but such prints may be somewhat improved by leaving in fixing bath from 30 to 60 minutes.

146. Blue tones or blue-black tones are obtained by using only sufficient bromide of potassium to clear the high lights.

147. Fog is caused by having the light too strong, by exposing for too long a time to the rays of a supposed safe light, or by using too little bromide of potassium. The amount of bromide of potassium recommended in formula is as little as should be used, but owing to varied conditions an increased amount may at times be found necessary. Except when printing, the paper should be handled at least 8 feet away from the source of light, and always be kept in package, where it is protected.

B. VELOX PAPERS.

148. Arrange three trays before you in this order:



149. Do not be too sparing of the amount of the solutions used, especially of your fixing bath (tray No. 3); if making three or four dozen prints (4 by 5) use a full pint; and do not keep it after using, as a fresh bath will give best results.

150. Proper temperature is important and for best results the developer should be 70° F. and the fixing bath and wash water 50° F. If the developer exceeds 70° the prints are liable to fog and the emulsion soften. If too cold, chemical action is retarded, resulting in flat, weak prints.

PRINTING.

151. Place the sensitized side of the sheet of Velox against the film side of the negative; the paper curls

slightly, the sensitive side being concave. An absolute test is to bite the corner of the sheet; the sensitive side will adhere to the teeth.

152. Place the printing frame the correct distance from the artificial light used, holding the frame away from the burner a distance equal to the diagonal of the negative. A few seconds' exposure will be required when printing an average negative on Special Velox. Regular Velox needs from four to five times as much exposure as Special, if in using both grades the printing frame is held at the same distance from the light.

153. The dry print should be immersed face up in the developer and quickly and evenly covered with the solution. Regular Velox should be developed 15 to 20 seconds; Special, about 30 seconds.

154. As soon as the image has reached the desired depth remove from the developer to the tray (No. 2) and rinse for a moment, turning the print several times, then place it in the acid fixing bath tray (No. 3), keeping the print moving for a few seconds, the same as was done when rinsing, so as to give even and thorough fixing, preventing stains and other troubles. Leave the print in this solution until thoroughly fixed; this will take about 15 minutes. When fixed, remove from the fixing bath and wash thoroughly for about an hour in running water, then dry. After drying, prints may be trimmed and mounted.

155. Care must be taken to prevent the Hypo in any way getting into the tray containing the developer. Have a clean towel when beginning the work and wipe your hands each time after you have handled prints in Hypo solution.

M-Q DEVELOPER.

(Dissolve chemicals in the order named.)

	Metric system.
Water	10 ounces=300 c. c.
Metol	7 grains=½ gram.
Hydroquinone	30 grains=2 grams.
Sulphite soda (desiccated)	110 grains=7 grams.
Carbonate soda (desiccated)	200 grains=13 grams.
10 per cent solution bromide potassium	40 drops=40 drops.

156. This solution will keep indefinitely if placed in bottles filled to the neck and tightly corked. It should be used full strength.

157. To secure permanency prints must be fixed in a fresh, acid fixing bath. When hypo is first dissolved in water, the temperature of the solution is materially reduced. It is important that the temperature of a fixing bath should be maintained as near to 50° F. as possible. Probably more prints change color from insufficient fixing than lack of washing, so these points should be given attention. Have plenty of solution strong enough to thoroughly fix prints in at least 15 minutes. Always use the acid hardener in the bath, as it will overcome the tendency of the fixing bath to cause blisters and stains.

158. Formula for preparing the acid hypo fixing bath is as follows:

Water	64 ounces.
Hypo-sulphite of soda (crystal or granulated)	16 ounces.

159. When thoroughly dissolved, add the following hardening solution, dissolving the chemicals separately and in the order named:

Water	5 ounces.
Sulphite of soda (desiccated)	½ ounce.
Acetic acid No. 8 (containing 25 per cent pure acid)	3 ounces.
Powdered alum	1 ounce.

160. This solution will keep, and 1 pint of it will fix at least one-half gross of 4 by 5 prints. If sulphite and carbonate of soda in crystal form are substituted for desiccated, double the quantities mentioned should be used.

NOTES ON WASHING.

161. The finished prints must be entirely free from Hypo. To wash a batch of one hundred 4 by 5 prints, using two trays of suitable size and transferring each print separately from one tray to the other, changing the water at least 12 times, will take a full hour for the process. In running water where the prints can be kept constantly moving so that each individual print has a thorough washing, from one-half to one hour, according

to the number of prints, will be required. Prints do not wash if piled in a bunch in a tray and the water simply runs in at one end of the tray and out of the other. In some localities where there is an excessive amount of iron or impurity in water the whites in the prints may have a slight yellowish tone. Prints should not be allowed to wash any longer than is necessary to completely free them from Hypo. The temperature of the water in winter should be kept as uniform as possible, as ice-cold water will cause blistering. When running water is used for washing, the stream should not be allowed to fall directly on the prints, as it will cause breaks in the fiber of the paper, producing blisters. Place a tumbler or graduate in the washing tray and allow the water to run into it and overflow into the tray. To determine when the print is thoroughly free from Hypo, the following test formula may be successfully employed:

Permanganate of potash	8 grains.
Caustic soda	7 grains.
Water (distilled)	8 ounces.

162. Fill a glass with pure water to which you have added three or four drops of the potash solution. Then take a couple of prints from the wash water and allow the water from the prints to drip into the glass. If Hypo is present, the violet color of the water in the glass will change to a slight greenish tint. In such case return prints to the wash water, to remain until similar tests show that the Hypo has been entirely eliminated.

DRYING.

163. After prints have been thoroughly washed, remove from the wash water and place on a clean glass in a pile, face down, and press out superfluous water. Then lay out separately, face down, on cheesecloth stretchers. These may be constructed by making a framework of light wood and tacking unbleached cheesecloth tightly over it. Prints dried in this manner will curl but a trifle.

164. If stretchers are not to be had, dry the prints, face down, on clean, uncolored cloths or towels which are free from lint.

165. Never dry Velox prints between blotters or on papers. They are likely to stick and cause much annoyance.

166. For mounting with paste the following plan is best to employ:

After prints are trimmed, immerse them in a tray of clean water, allowing them to soak long enough to become thoroughly limp. Remove to a good-sized piece of clean glass, placing them in a pile, face down. Cover with a piece of clean blotting paper, and with a roller squeegee press all the superfluous water from the pile. Then with a good bristle paste brush apply a thin, even coating of starch paste. Raise the print by taking hold of the two opposite corners and turning it over; place in position on the mount. Lay a clean, dry blotter over the print and with the roller press into contact. Any lint or fuzz from the blotter, or any paste on the surface of the print, should be immediately removed with a soft sponge or dampened cloth. When dry, shape the mounted print by running it through a cold burnisher. Any imperfections in the finished print may be corrected by spotting, using a fine sable brush and spotting color of india ink.

HOW TO MAKE PRINTS FROM WET NEGATIVES.

167. The negative must be thoroughly washed and freed from any trace of Hypo. Immerse a piece of Velox paper in clean water for a few seconds, then, placing it on the film side of the wet negative, squeegee it carefully so as not to break the film. Expose without the use of a printing frame. After exposure, place both negative and paper in water, allowing them to soak for a moment before trying to separate them. Develop and fix the print in the usual way.

C. P. M. C. BROMIDE PAPER.

168. Read directions carefully before using.

The exposure of P. M. C. bromide paper varies with the density of the negative and the quality and intensity of the light used.

Developer.

	Avoirdupois.	Metric.
		Grams.
Amidol	60 grains	4
Sulphite soda, granular	1 ounce or hydrometer test, 14	30
Water	32 ounces	1,000

169. To every 8 ounces ready developer add 20 minims of a 10 per cent solution of bromide of potassium. It may be used several times in succession, provided it remains clear. For very strong negatives the bromide of potassium should be omitted and the developer weakened by increasing the amount of water. For soft, weak negatives the quantity of bromide of potassium may be doubled.

170. With this developer no clearing solution is necessary; as soon as the print is fully developed rinse off with two or three changes of fresh water and immediately place in the following:

FIXING BATH.

Water	64 ounces.
Hypo soda	8 ounces.

171. It is advisable to mix this up several hours before using, or, better still, the night before. The use of a freshly made fixing bath is frequently the cause of blistering.

172. An acid fixing bath will yield clearer and more brilliant prints than a neutral or alkaline bath; to accomplish this add 5 minims of acetic acid to every ounce of hyposulphite of soda used. Alum may be substituted in place of the acetic acid, as it also serves the purpose of toughening the film. In using alum, add one-quarter ounce to every 2 ounces of hypo soda.

NOTES.

173. Weak, light prints are the result of under exposure, or from the use of an exhausted developer.

174. Dark, muddy, or mealy prints are caused by overexposure.

175. For best results it is advisable to use a fresh fixing bath every day.

AZO DEVELOPING POWDERS.

(For bromide papers.)

176. Ready for use.

Twelve powders, sufficient for 48 ounces ready developer.

Six powders, sufficient for 24 ounces ready developer.

Full directions accompany each package.

DIRECTIONS.

177. The Eastman Co. recommends amidol or metol hydro developer for use with all of its bromide papers.

AMIDOL DEVELOPER.

(Concentrated solution.)

178. The concentrated stock solution is prepared by dissolving in succession in:

12 ounces	Water.
1½ ounces	Sulphite soda, des.
½ ounce	Amidol.

179. Enough of this stock solution should be prepared at one time for only one day's use.

TO DEVELOP.

180. Take in a suitable tray:

Concentrated stock solution	1½ ounces.
10 per cent solution bromide of potassium	8 drops.
Water	6 ounces.

METOL HYDRO DEVELOPER.

(Concentrated solution.)

48 ounces	Water.
½ dram	Metol.
10 drams	Sulphite soda, des.
2 drams	Hydroquinone.
1 dram	Bromide of potassium.
20 drams	Carbonate soda, des.

181. If sulphite and carbonate sodas in crystal form are substituted for desiccated, double the quantities mentioned should be used.

TO DEVELOP.

182. Take in a suitable tray:

Concentrated solution	4 ounces.
Water	4 ounces.

183. Use developer at a temperature of about 70° F. After exposure, soak the paper in water until limp and brush lightly over the surface, while wet, with a tuft of cotton and flow developer over the print.

184. The image should appear slowly and should develop up strong, clear, and brilliant. When the shadows are sufficiently black, pour off the developer and rinse the print thoroughly with pure water. Increasing the amounts of bromide potassium given in the formulæ is sometimes necessary to prevent grayish high lights.

185. Immerse prints for 10 minutes in the

FIXING BATH.

Hyposulphite soda	3 ounces.
Water	16 ounces.

186. After fixing, wash thoroughly for two hours and hang up to dry.

187. A fresh fixing bath should fix twenty-four 8 by 10 prints or equivalent.

IMPORTANT DETAILS.

188. *Clean dishes and clean hands.*—The faintest trace of hyposulphite of soda or of pyrogallic acid is fatal to good results with bromide paper, and the operator can not be too careful to avoid any contaminations.

189. Do not use amidol solution that is more than 24 hours old.

190. Fresh hypo solution is required for fixing each batch of prints.

191. The washing must be thorough after fixing.

192. Blisters sometimes appear in bromide paper, and may be avoided by using a little common salt in the first washing water after fixing.

193. Mealy prints are caused by overexposure.

194. Other developers (except pyrogallic acid) may be used to develop Eastman's bromide papers, formulas for the use of which accompany the chemicals.

195. Small white spots and streaks are caused on matte-enamel and platino papers by developer not taking evenly. To overcome, before pouring developer on print take a camel's-hair brush or piece of cotton and brush over the whole print while it is immersed in water.

CONTACT PRINTING.

196. Gas, lamp or candle light may be used. Strong, intense negatives are best printed by strong light.

197. The exposure varies with the intensity of the negative and the quality and intensity of the light, but may be approximately stated to be, using as thin a glass negative or film as will make a good print, 1 second by diffused daylight, or 10 seconds at a distance of 1 foot from a No. 2 kerosene burner.

XI. MISCELLANEOUS.

A. FORMULA FOR SENSITIZING BLUE-PRINT PAPER.

198. Prepare the following solutions separately:

1.	Water	8 ounces.
	Red prussiate of potash	1¼ ounces.
2.	Water	8 ounces.
	Iron and ammonium citrate	2 ounces.

Mix equal parts of the above solutions together.

B. FIXING BOTH FOR MADURA PAPER.

Water	8 ounces.
Hyposulphite of soda	1 ounce.

C. STARCH PASTE.

199. Ordinary gloss starch dissolved in just enough cold water to make a thick solution is prepared, and enough boiling water poured into it so that it thickens in a clear, translucent jelly. Set aside and when cool remove the skin which forms and use the clear paste.

XII. MILITARY USES OF PHOTOGRAPHY.[1]

200. In military operations photography will find its principal use in obtaining—

(*a*) Views forming a key for range charts.

(*b*) Views to illustrate reports of operations and reconnaissance parties.

(*c*) Views to illustrate conditions at points where special engineer operations (bridge or railway construction, etc.) are likely to be necessary.

(*d*) Accurate perspective representations of the prominent features of the landscape to be used as a basis for control of military maps.

(*e*) Photographs taken from aeroplanes, for the location of new positions of enemy's batteries, intrenchments, etc.

201. For the purposes under the heads (*a*) and (*b*), free-hand outline perspective sketches are preferable to photographs; because the mass of detail and prominent unimportant objects in the foreground, appearing in photographs, obscure the details of the background which are usually of greater military importance. However, the taking of a photograph requires a much shorter occupation of the observing point and an expert sketcher is not needed for the purpose.

202. To be of any military value, views coming under the headings (*a*), (*b*), and (*c*) must permit of accurate orientation of the photograph on available maps and in this regard they should comply with the requirements as to the direction of the axis and leveling of the camera prescribed hereafter for photographic surveying.

203. In the presence of the enemy a survey or reconnaissance party will reach a point beyond which the country can not be traversed. The locus of such points sets a practical limit to the extension of mapping operations in the original manner; but if accurate perspective representa-

[1] The parts of this chapter on photographic surveying are based on Chapter VI of "Higher Surveying," by Breed and Hosmer.

tions of the ground seen from a series of points along this limiting line be procured, a fairly accurate map of the inaccessible terrain may be plotted by resection from the perspective pictures. The photographic camera offers a way of obtaining quickly and mechanically such a series of perspective pictures. The rapidity and accuracy with which this map can be plotted will depend upon the care with which the camera positions were selected, the precision of the adjustment and orientation of the instrument for each view, and the skill and facility (gained by experience) of the draftsman.

204. The issue cameras can be used for such photographic surveys as may be required during military operations without other special apparatus than an improvised device for leveling the instrument. A simple manner of providing for this consists in mounting the camera rigidly to a board provided with three leveling screws, at the vertices of an equilateral triangle, and two spirit levels, one at right angles to the plane of the film or plate and the other parallel to this plane. The camera so mounted can then be laid on the Engineer sketching board, which should be approximately leveled by adjustment of the tripod.

205. Occasions may arise when a map of the terrain in rear of the firing line is required and the nature of the country is such as to make ordinary instrumental survey methods very slow or very expensive. Under these circumstances photographic survey methods may prove a convenient solution of the problem.

206. *Special terms.*—The relationship existing between points in the landscape, the film or plate of the camera, and the photograph is diagrammatically indicated in figure 9.

The actual points on the ground are indicated by L and L′.

Their position on the film or plate (negative) is indicated by N and N′.

The position of the same points in the photographic print is indicated by P and P′.

The optical center of the lens is indicated by O.

The focal distance of the camera is the normal distance from O to the plane N N′.

The horizon line is the intersection of a level plane through the point O and the plane of the photograph (P P′).

The principal line is the intersection with the plane of the photograph of a vertical plane perpendicular to the plane of the picture.

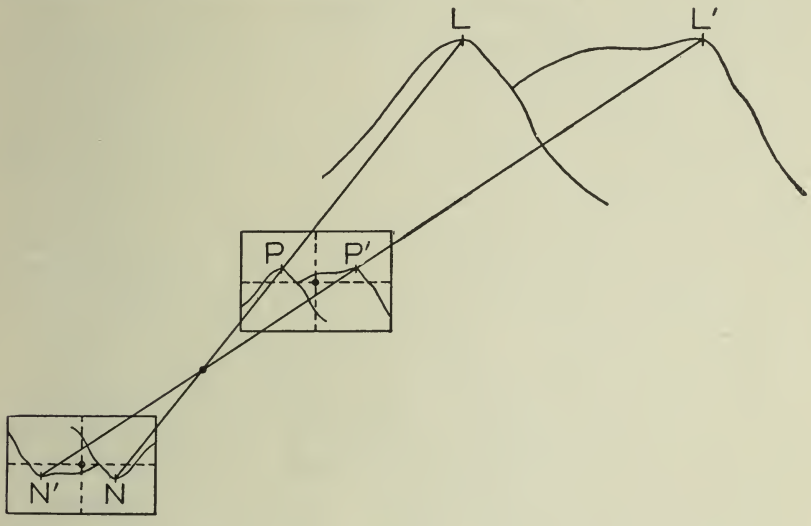


FIG. 9.

The principal point is the intersection on the photograph of the horizon line with the principal line.

207. *Camera positions.*—Camera positions must be so selected that prominent points appear in at least one picture from each of two camera stations. For check as to accuracy of the work, all camera stations should appear in photographs taken from at least three other camera stations, and if a few other prominent points can also appear in three views the accuracy of the map will be enhanced. The best location for a camera station is the top of a hill, moderately high, about halfway between the lowest ground and the highest part of the sky line. Extremely high camera positions will crowd too much of the terrain into the lower half of the picture and too low

a position will restrict the view, because of interference of objects in the foreground.

208. *Constants and adjustments.*—Having provided the camera with a means of leveling it, the following adjustments and determinations of instrumental constants are necessary:

209. *Adjustments of the bubble which is perpendicular to the plane of the film.*—The bubble which is perpendicular to the plane of the film or plate should be so adjusted that when the plate is vertical the bubble is central; or else a reading of the bubble should be noted which corresponds to the vertical position of the plate, and this position of the bubble should be marked in some way on the glass tube. To determine the vertical position of the plane of the film set up a leveling instrument in front of and at the same height as the camera and find some distant point which is on the horizontal cross hair. Turn the level around on its vertical axis until it points toward the camera. Level the camera and place a ground glass plate or a piece of tracing paper accurately in the position ordinarily occupied by the film or plate. Turn the camera so that the reflection of the distant object from the back surface of the plane of the film can be seen through the telescope of the leveling instrument. If the plane of the film is vertical the image of this object will appear somewhere on the horizontal cross hair of the leveling instrument; if it is not, the camera must be tilted until this condition is fulfilled. Then the level tube may be adjusted; if it is not adjustable, the scale readings of the ends of the bubble must be noted or, preferably, marked in some way on the tube.

210. The camera may then be placed on the tripod so that the long dimension of the plate is vertical, and a similar adjustment of the level perpendicular to the plate may be made for this position of the camera.

211. *Determining the position of the principal point.*—After the bubbles are adjusted so that the plate can be made vertical, a transit or a leveling instrument is set up and leveled, and two well-defined points on the horizon are

found which, when photographed on one plate, will come near its opposite edges. The camera is set at the same height as the leveling instrument, with the long axis of the film horizontal; the level bubble which is perpendicular to the plane of the film is then centered and a plate or film is exposed. A line drawn on the negative through the photographs of these points determines a horizontal line. The camera is now placed on the tripod at right angles to its first position (with long axis of the film vertical) and the operation repeated, two new points at the same height as the camera being selected, if necessary, to bring them within the limits of the picture. A line through the points on the second negative is a horizontal line for this second position. The line on the second negative may now be transferred to the first one by means of measurements made along the edges of the exposed portion of the plate or film. The intersection of these two lines, both of which are now on the same negative, will determine the position of the principal point. Since the bubbles which are parallel to the plate have not been adjusted these two lines are not necessarily at right angles to each other.

212. In case it is impossible to find distinct points exactly on the true horizon, any well-defined points (preferably near the horizon) may be chosen and vertical angles may be measured to these points. The vertical distance on the print from these points to the horizon line may be computed by use of the azimuths, vertical angles, and the focal distance. If these vertical distances are laid off on the print they will give a series of points which will be on the true horizon.

213. *Determining the positions of horizon and principal lines.*—Now that the principal point has been determined the horizontal and principal lines may be laid out by means of measurements along the edges of the exposed part of the plate or film. If the arrangement of the camera permits, a black paper or wooden frame, the inside edges of which will limit the amount of plate or film exposed, should be inserted in front of and against the plate or film. Notches in the inside edges of this frame,

which will appear in the photograph, should now be cut to indicate the extremities of the two lines perpendicular to one another which intersect at the principal point. The horizon and principal lines may then be drawn on any print by simply joining by straight lines on the print the photograph of these notches.

214. *Adjustment of the bubble which is parallel to the plane of the film.*—The level which is parallel to the plane of the film should be so adjusted as to be central when the horizon line is truly horizontal, or else a reading on the level bubble should be found which corresponds to this horizontal position.

This may be done by tipping the camera until the bubble is at one end of the tube and then taking a photograph of the points which have already been used in fixing the horizon line. This will show the horizon line inclined to the actual horizon. The camera is then inclined until the bubble is at the other end of its tube, and another plate is exposed. This second plate will also show the horizon line inclined to the true horizon, but in the opposite direction. The exact position of the level bubble should be noted in each case. After measuring on the edges of the plate the distance from each notch to the horizon as determined by the photographed points, simple interpolation between the bubble readings and between the measured distances will show what the bubble should read when the horizon line defined by the notches is level. If the level is adjustable the bubble should be made central while the camera is in the correct position. During the above adjustment the plate should be kept vertical by means of the bubble which is perpendicular to the plate.

215. *Determining the focal length of the lens.*—The focal length is usually given by the instrument maker, but it may be found in the field by either of the following methods.

216. *First method.*[1]—Set a transit over the camera station and measure the angle AOB between two distant

[1] This is the method given by Capt. E. Deville, surveyor general of dominion lands, in "Photographic Surveying," published by the Government Printing Bureau at Ottawa.

points A and B. In figure 10 let AOB=$\alpha+\beta=\omega$. Expose a plate and measure on the negative the distance x and y

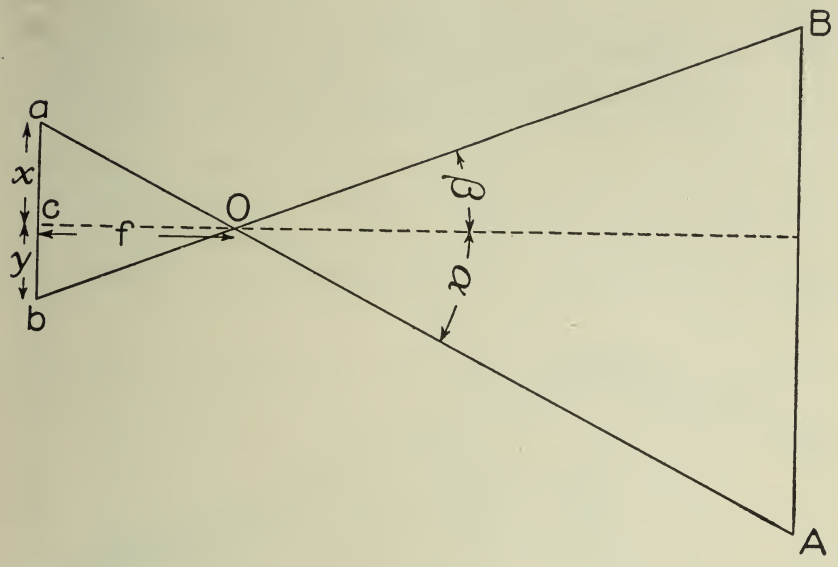


FIG. 10.

from the points a and b to the principal line at c. Let f=Oc. Then

$$\tan \alpha = \frac{x}{f}$$

$$\tan \beta = \frac{y}{f}$$

and

$$\tan \alpha \tan \beta = \frac{xy}{f^2}$$

$$\tan (\alpha+\beta) = \tan \omega = \frac{\frac{x}{f}+\frac{y}{f}}{1-\frac{xy}{f^2}}$$

hence

$$f^2 - \frac{x+y}{\tan \omega} \cdot f - xy = 0$$

Solving this equation gives

$$f = \frac{x+y}{2 \tan \omega} + \sqrt{\frac{(x+y)^2}{4 \tan^2 \omega} + xy}$$

217. *Second method.*—Set up the camera and level it; set two poles, or select two well-defined points, A and B, figure 11, on the same level as the camera, the two being equally distant from the camera, and photograph them. The angle AOB should not be very acute if an accurate determination of the focal length is desired. Measure the

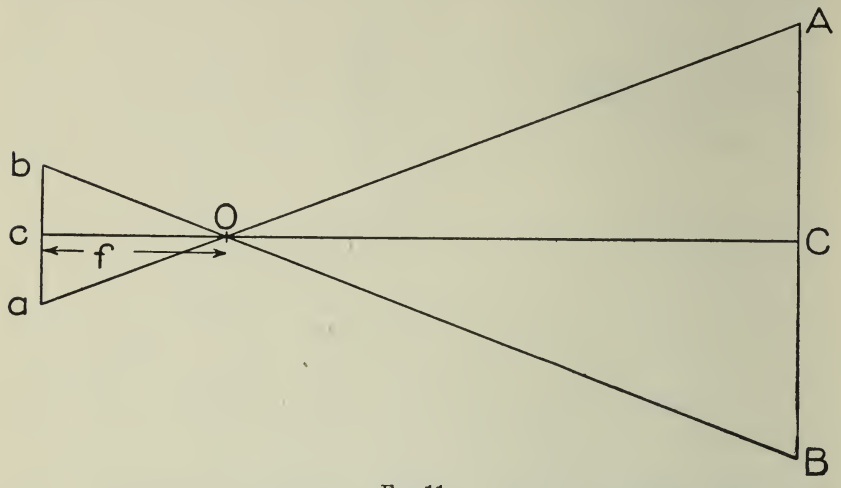


FIG. 11.

distances AB, cC, and ab. The first two should be measured with a tape and the third scaled from a negative. Then

$$CO+cO=cC$$

and

$$CO:AB=cO:ab$$

From these equations is found the value of cO, or f. The poles should be far enough away for the focus to be practically the same as it will be for the surveying work.

218. In order to detect distortion in the photographic prints, distances equal to $\frac{1}{2}$ f and $\frac{1}{4}$ f respectively are laid off on the long and short sides of the rectangular opening at the back of the camera and marked by notches similar to those used in marking the horizon and principal lines. In this way distances of $\frac{1}{2}$ f and $\frac{1}{4}$ f are shown on all prints and any change in the dimensions of the print may be measured and allowed for.

219. *Plotting.*—The first step to be taken in preparing the map is to plot the camera stations. Before any of the details can be plotted it is necessary to locate on the map the position of the picture trace, or ground line, for each photograph taken. This trace is the intersection of the picture plane with the plane of the map when the print is vertical and at a distance from the camera station equal to the focal length of the lens, and in such a position that every point on the print has its proper azimuth from the camera station. It is evident that when the print is in this position the principal plane is perpendicular to the

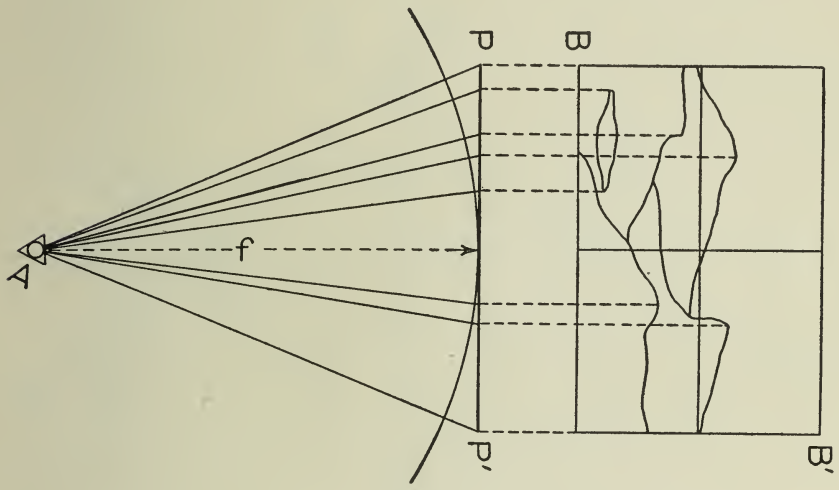


Fig. 12.

print and that the picture trace is tangent to a circle with radius f drawn about the camera station as a center. In figure 12, A represents the plotted position of the camera station; B B′ is a photograph (lying on the map) taken from A, and P P′ is the picture trace. If the print is held in a vertical position on the picture trace, the azimuth of every point on the print as seen from the plotted position of the camera station will be the same as it is in the field. The process of locating the picture trace is called orienting the picture, and it should be done accurately, because all subsequent plotting from this picture will depend upon this location of the trace.

220. *Orienting the picture trace.*—In order that the picture trace may be oriented it is necessary to know the position of the horizon and principal lines and also the focal length of the lens. In addition to this the position of the camera station on the map must be known (from previous survey or from photographs taken from other camera stations, see par. 259), and the print must contain the photograph of at least one point whose direction from the camera station has been determined.

221. In figure 13 suppose that a base line AB has been plotted in the position ab. Let the focal length f equal

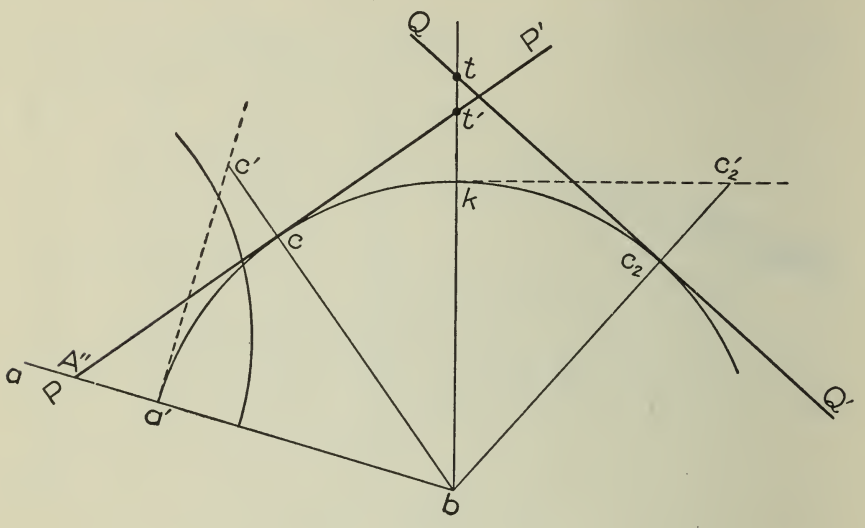


FIG. 13.

bc, sometimes called the distance line. About a and b as centers draw circles of radius f. If different cameras have been used at the two stations the circles must each have a radius equal to the value of f for the camera used. The focal length laid off must be the actual length, no matter what scale is chosen for the map. Let us suppose that the first photograph taken from station B includes the picture A and let figure 14 be the print so taken. Any point on the picture may be projected down on to the picture trace by means of a vertical line, and so far as the horizontal location of points is concerned it may be

considered that they lie on the picture trace. When the picture is placed in position the principal point c on the trace (fig. 13) must be on the circumference of the circle about b, and the photographed position of A must be somewhere on the line ba, produced if necessary. To find the position of the picture trace, erect, a′ c′ perpendicular to ba′, scale from the print the distance cA′ (fig. 14), and lay it off on this perpendicular; this gives point c′. Draw a line from c′ to the center b. Point c, where the line cuts the circle, is the center of the picture trace. Through

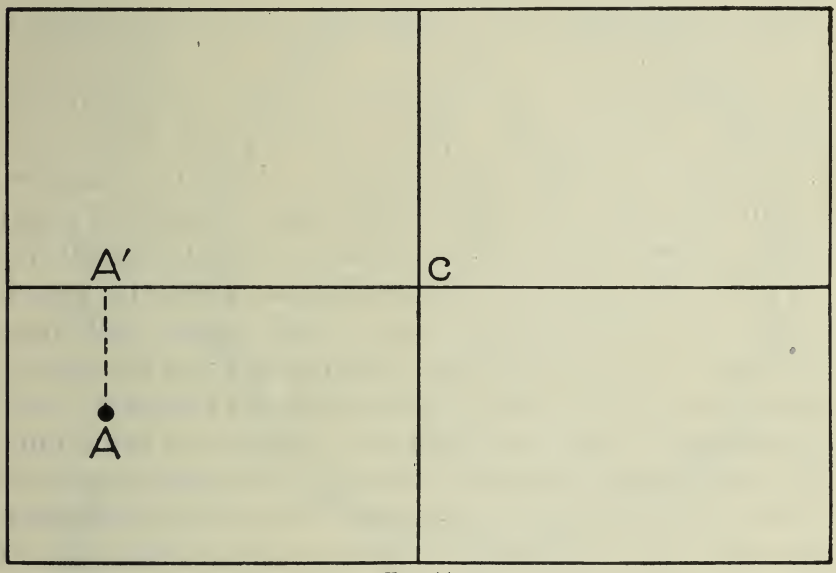


FIG. 14.

c draw a line perpendicular to bc; this is the picture trace. Point A″ is the position on the picture trace PcP′ corresponding to the position of A on the ground. PcP′ is the picture trace desired, because it is perpendicular to the principal plane bc at point c; and c is the principal point because cA″=c′ a′ (fig. 13)=cA′ as scaled from the print (fig. 14).

222. A second picture trace may be located from this one if there is on the right side of this first picture some point which is also on the left side of the next picture. The geometric construction for locating the second photograph is

similar to that used in orienting the first. In figure 13, T is a point which appears on two adjacent prints, PP′ and QQ′. The trace QQ′ is determined on the map by means of point t′, which is the position of T on the trace PP′. Where the line tb cuts the circle at k erect a perpendicular kc_2', the distance kc_2' being obtained from the second photograph just as a′ c′ was obtained from the print shown in figure 14. The line $c_2'b$ cuts the circle at c_2, which is the principal point of the second picture trace. The line bt cuts QQ′ at t, which is the position of T on the second trace.

223. In case the focal length of the lens is not known, or if it is desired to verify its length, the picture trace may be located by the following method, provided that there are several points shown in the print which have been connected with triangulation points by measured horizontal angles. On the straight edge of a strip of paper mark a point representing the trace of the principal line and from this point lay off the distance from the principal line to each of the points to which angles have been measured. Draw radial lines on the plan from the camera station toward the points sighted with the transmit, using the measured angles to obtain the direction of the points. The strip of paper may now be laid on the plan and moved about until each point on the paper lies on the corresponding radial line on the plan. This position of the edge of the paper is the true position of the trace, and the distance from the plotted camera station to the principal point on the strip is the focal length, or distance line. The distance line should, of course, be perpendicular to the trace. In order that the focal length may be determined accurately by this method, two of the points sighted should lie near opposite edges of the print.

224. Since the prints are liable to become distorted, measurements which must be obtained with great accuracy, such as those for obtaining the focal length, should be scaled directly from the negative. For locating details it will be sufficiently accurate to scale from the print and to

make allowance for the distortion as shown by the notches on the edge of the print.

225. In the field the labor of locating the trace of each picture may be eliminated by construction on tracing paper a camera protractor as shown in figure 15, drawn on a piece of tracing paper. The radius of the circle=f. The circumscribed regular polygon is selected so that the length of each side is a convenient amount less than the length of the exposed part of the film or plate; this will

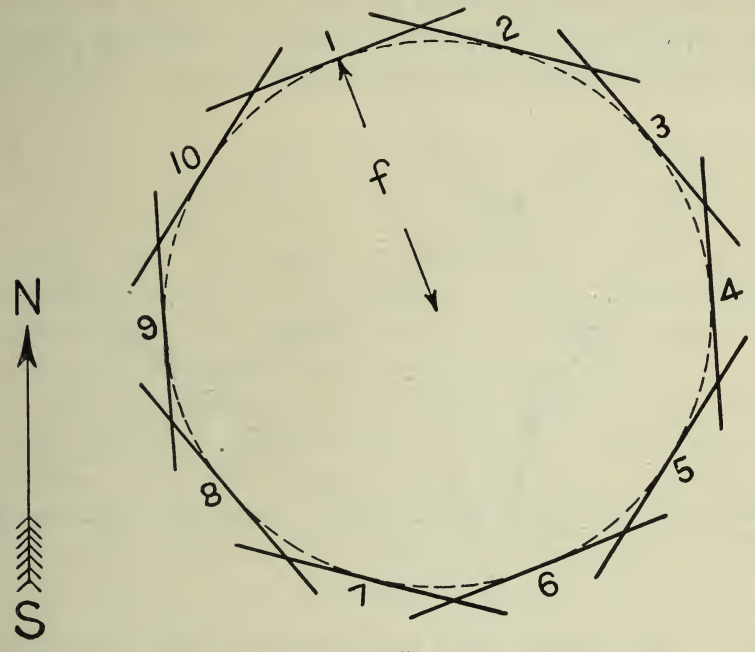


FIG. 15.

insure each photograph's overlapping adjacent ones. The line NS represents a north and south line. On occupying a camera station the plane table sketching board is set up and oriented by back sights to known objects. The camera protractor is then laid on top of the sketching board and oriented on the map with the help of the NS line. Photographs are then taken, placing the camera so that the film or plate will be successively parallel to the sides 1, 2, 3, 4, etc. This is most easily done, if the board (on which the camera is mounted for leveling) be finished

with one beveled edge parallel to the plane of the film. This straight edge can then be placed for each photograph so as to coincide with one side of the polygon on the camera protractor. To plot the photographs it is only necessary to orient the camera protractor over the plotted position of the camera station and to prick through the vertices of the polygon, the sides of which are the traces of the photographs.

226. *Locating points on the map.*—Any point of the first picture may be plotted on the line PcP′ (fig. 13) by scaling on the print the horizontal distance from the principal line and by laying off this distance from c on the trace

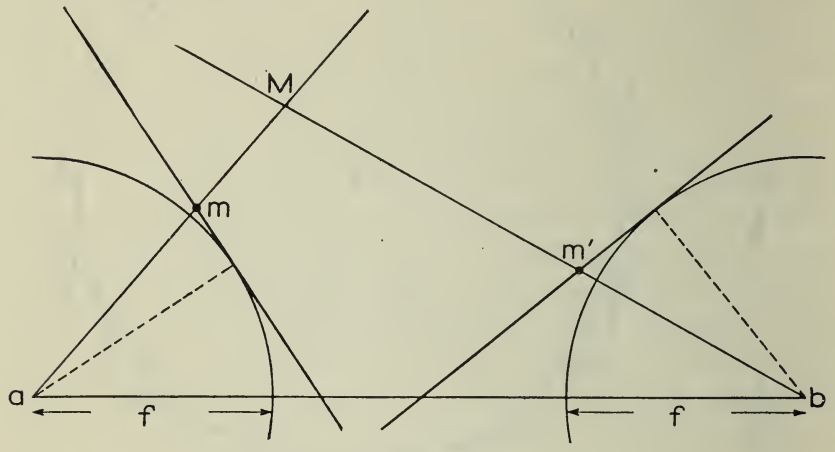


FIG. 16.

PcP′. By drawing lines from b to the points thus plotted on the picture trace a set of radiating lines is obtained, showing the directions of these points as seen from B, and the location of these points on the map will be somewhere on the corresponding radial lines.

227. By means of a photograph from A containing these same points the trace of this photograph may be oriented on the circle about a in the same manner as that described for the point b. (See fig. 16.) This locates these same points on another set of radiating lines drawn from a, and the intersection of corresponding lines from a and b, such as am and bm′, locates the point, M, on the map.

228. Where there are many points to be plotted from one base line a convenient method is to first transfer to the straight edge of a strip of paper the principal point of one of the prints and to lay off from this point the distances to all the other points to be plotted. This paper can be fastened in the proper position on the plan to serve as the picture trace. A similar strip is constructed for each photograph taken, and fastened in its proper place on the map. Points may then be located on the plan by fastening two fine threads to needles stuck in the end points of the base line, passing these threads through corresponding points on the traces, and marking the intersection on the plan.

229. From the points so located the details may be sketched, the topography being judged from the appearance of the prints. There is no limit to the number of points that may be located, provided these points can be positively identified on the prints. Points which can be identified should be marked with the same numbers on the different prints for convenience in plotting.

230. *Determination of elevations from the photographs.*—Differences in elevation may be found graphically or by computation, the former being the more common method. The distance of a point above or below the horizon line may be scaled from the print; this vertical distance divided by the horizontal distance from the plotted camera station to the point on the trace is the natural tangent of the angle of elevation or depression. It is necessary that the actual horizontal distance from the camera to the point should be known before the elevation of the point can be determined. This horizontal distance may be scaled from the map after the point has been located by the method already described. The difference in elevation between the camera and the point may be found by simple proportion as follows:

231. Figure 17 shows the plate with the horizon and principal lines drawn upon it. A is the point whose elevation above the camera station O is desired. Figure 18 is

a portion of the map, O is the lens, and PP′ is the trace of this picture on the map. In both figures 17 and 18, c is the center of the print, B is the point vertically under A, and OB is the horizontal distance from O to A. If in figure 18 a perpendicular BA′ is laid off at B, this perpendicular being equal to the distance AB scaled from the print, then the angle A′ OB is the true angle of elevation of A above a horizontal plane through O. The plotted position of A will lie on the line OB on the plan. If a is assumed to be the plotted position of A, and aa′ is drawn

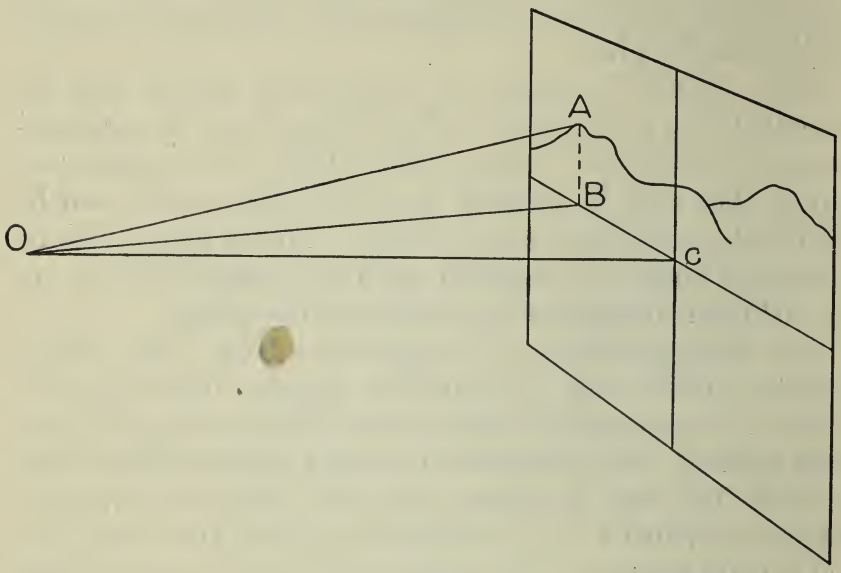


FIG. 17.

perpendicular to OB, and if aa′ is measured with the same scale as that used in laying out the base line, the result will be the actual difference in elevation between O and A. The distance aa′ could of course be computed by proportion if desired, the data being the actual distances OB and BA in inches (OB being scaled from the map and BA from the print) and the distance Oa in feet as scaled from the map.

232. *Contours.*—Contours may be sketched by obtaining the elevations of controlling points and then judging the variations in slope between the points by the appearance of the photographs. Sometimes the contours are first

sketched on the photographs by making use of the elevations already determined, and then these contours are drawn on the map. Since there is a large amount of

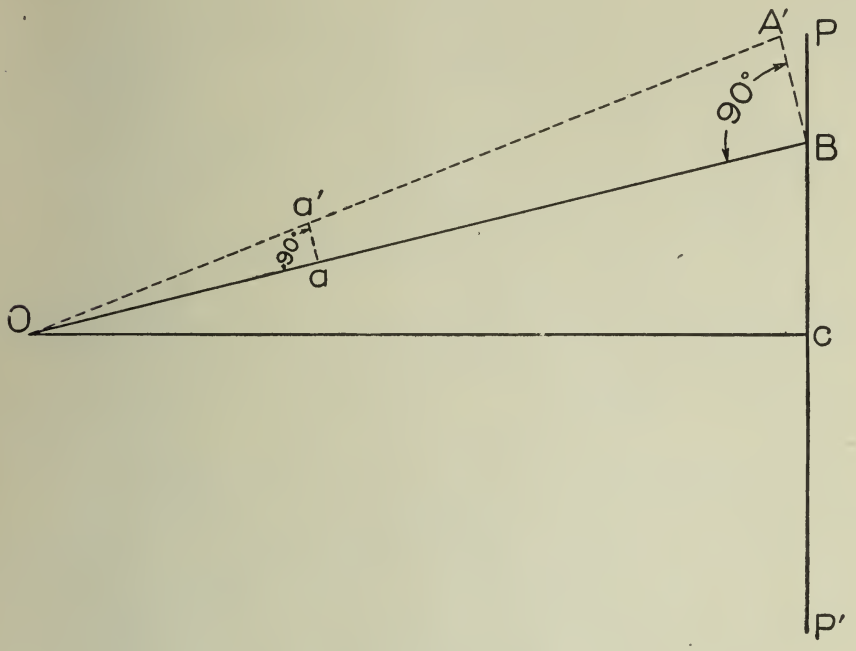


Fig. 18.

sketching involved, and since such a map must be generalized to a great extent, a knowledge of the geological formation of the country will be of great assistance in determining the characteristics of the contours.